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DOE/NASA CONTRACTOR  
REPORT

DOE/NASA CR-161557

SOLAR HEATING AND HOT WATER SYSTEM INSTALLED AT  
SHONEY'S RESTAURANT, NORTH LITTLE ROCK, ARKANSAS -  
FINAL REPORT

Prepared from documents furnished by

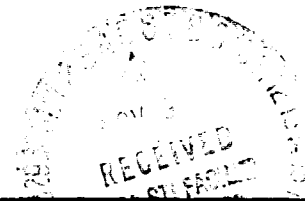
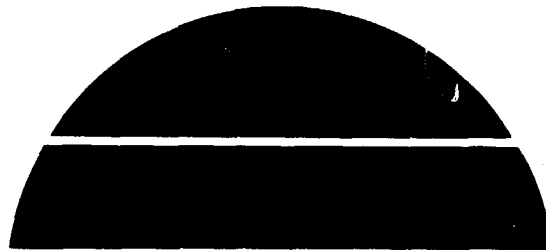
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Under DOE Contract EM-78-FO1-5188

Monitored by

National Aeronautics and Space Administration  
George C. Marshall Space Flight Center, Alabama 35812

For the U. S. Department of Energy



(NASA-CR-161557) SOLAR HEATING AND HOT  
WATER SYSTEM INSTALLED AT SHONEY'S  
RESTAURANT, NORTH LITTLE ROCK, ARKANSAS  
Final Contractor Report (Shoney's South,  
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**U.S. Department of Energy**



**Solar Energy**

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16. ABSTRACT  This document is the final technical report of the Solar Energy System located at Shoney's Restaurant North Little Rock, Arkansas.  The solar heating system is designed to supply a major portion of the space and water heating requirements for a newly built Shoney's Big Boy Restaurant which was installed with completion occurring in December 1979. The restaurant has a floor space of approximately 4,650 square feet and requires approximately 1500 gallons of hot water daily. The solar energy system consists of 1,428 square feet of Chamberlain flat plate liquid collector subsystem, and a 1500 gallon storage subsystem circulating hot water producing $321 \times 10^6$ Btu/Yr (specified) building heating and hot water heating. Designer - Energy Solutions, Incorporated. Contractor - Stephens Brothers, Incorporated.  This report includes extracts from site files, specification references for solar modifications to existing building heating and hot water systems, drawings installation, operation and maintenance instructions.			
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SOLAR SPACE AND WATER HEATING FOR SHONEY'S  
RESTAURANT IN NORTH LITTLE ROCK, ARKANSAS

ABSTRACT

Application	-	space and water heating
System Type	-	active
Collector Type	-	flat plate liquid
Collector Manufacturer	-	Chamberlain
Collector Area	-	1428 (gross)
Storage Capacity	-	1500 gallons
Building Load	-	$551 \times 10^6$ BTU/YR
BTU's Produced	-	$321 \times 10^6$ BTU/YR
Building Owner	-	Shoney's South, Inc.
Designer	-	Energy Solutions Incorporated
Contractor	-	Stephens Brothers, Inc.

INTRODUCTION

A solar heating system designed to supply a major portion of the space and water heating requirements for a newly built Shoney's Big Boy Restaurant in North Little Rock, Arkansas was installed with completion occurring in December, 1979.

The restaurant has a floor space of approximately 4650 square feet and requires approximately 1500 gallons of hot water daily. Figure 1 shows the east elevation of the restaurant with the four rows of flat plate solar collectors mounted on the roof. Not shown in the figure is an architectural screen around the roof periphery to enhance the overall aesthetics of the building.

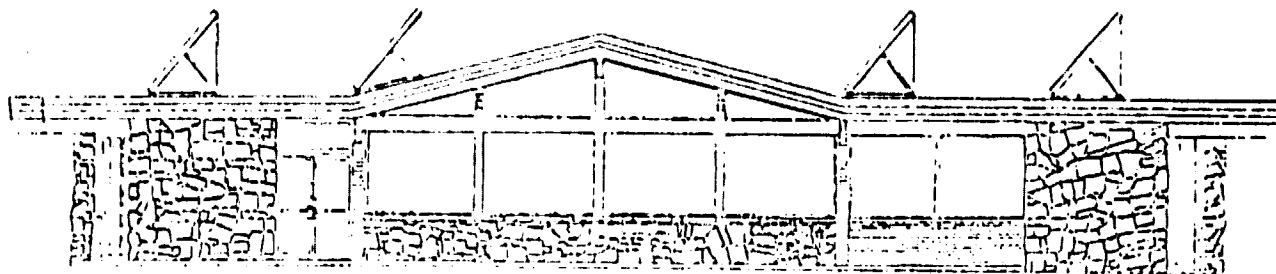


FIGURE 1. EAST ELEVATION OF RESTAURANT WITH SOLAR COLLECTORS IN PLACE.

#### DESIGN PHILOSOPHY

Based on the predicted thermal load of the building the annual solar fraction was determined as a function of solar collector area. These results are shown in Figure 2, and in combination with appropriate economic considerations led to a design area of 1428 square feet (gross) of single-glazed liquid flat plate solar collector.

Similar calculations were performed to determine the optimum tilt angle for the collectors. The optimum angle was found to be  $35^{\circ}$  (site latitude =  $35^{\circ}$ ), but system performance was found to be rather insensitive to tilt angle when the angle was between  $25^{\circ}$  and  $60^{\circ}$ . Architectural considerations led to a design in which two rows of collectors are tilted at  $35^{\circ}$  while the remaining two are tilted at  $25^{\circ}$ .

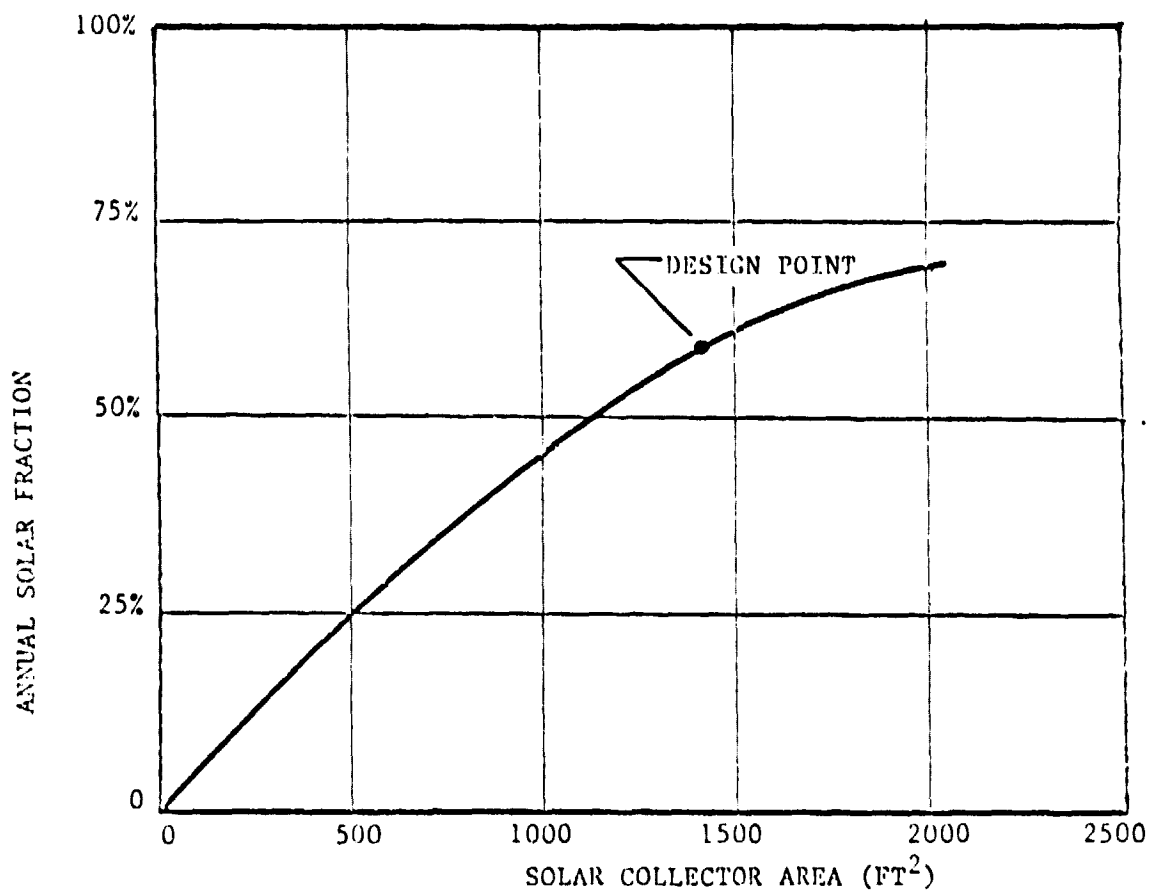


FIGURE 2. ANNUAL SOLAR ENERGY FRACTION VERSUS COLLECTOR AREA.

Figure 3 shows the combined space and water heating load as a function of time of year along with the solar energy supply. As can be seen, most of the collected energy can be used by the restaurant.

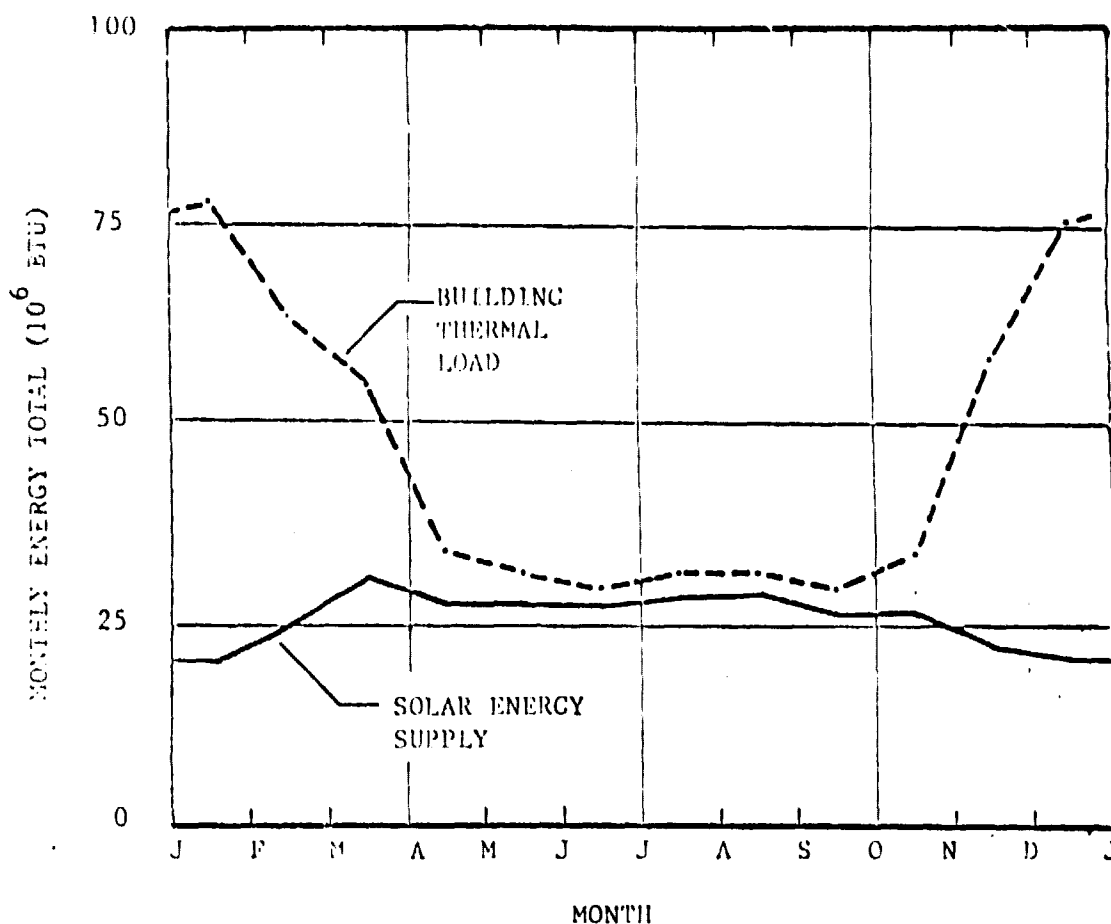


FIGURE 3. BUILDING THERMAL LOAD AND SOLAR ENERGY SUPPLY

Because of the continual demand for domestic hot water at the restaurant, storage is less of a concern than in many other applications. The system employs a 1500 gallon steel storage tank located within an equipment room of the restaurant.

Figure 4 shows a schematic of the final system design. As can be seen, a hydronic coil located in the main supply air duct transfers heat from the solar storage tank to the building. Likewise, an external heat exchanger is used to transfer heat from storage to the conventional electric hot water heater.

Freeze protection is provided via an ethylene glycol/water mixture in the collector loop. Contamination of potable water is prevented through the use of two heat exchangers between the collector fluid and the potable water supply.



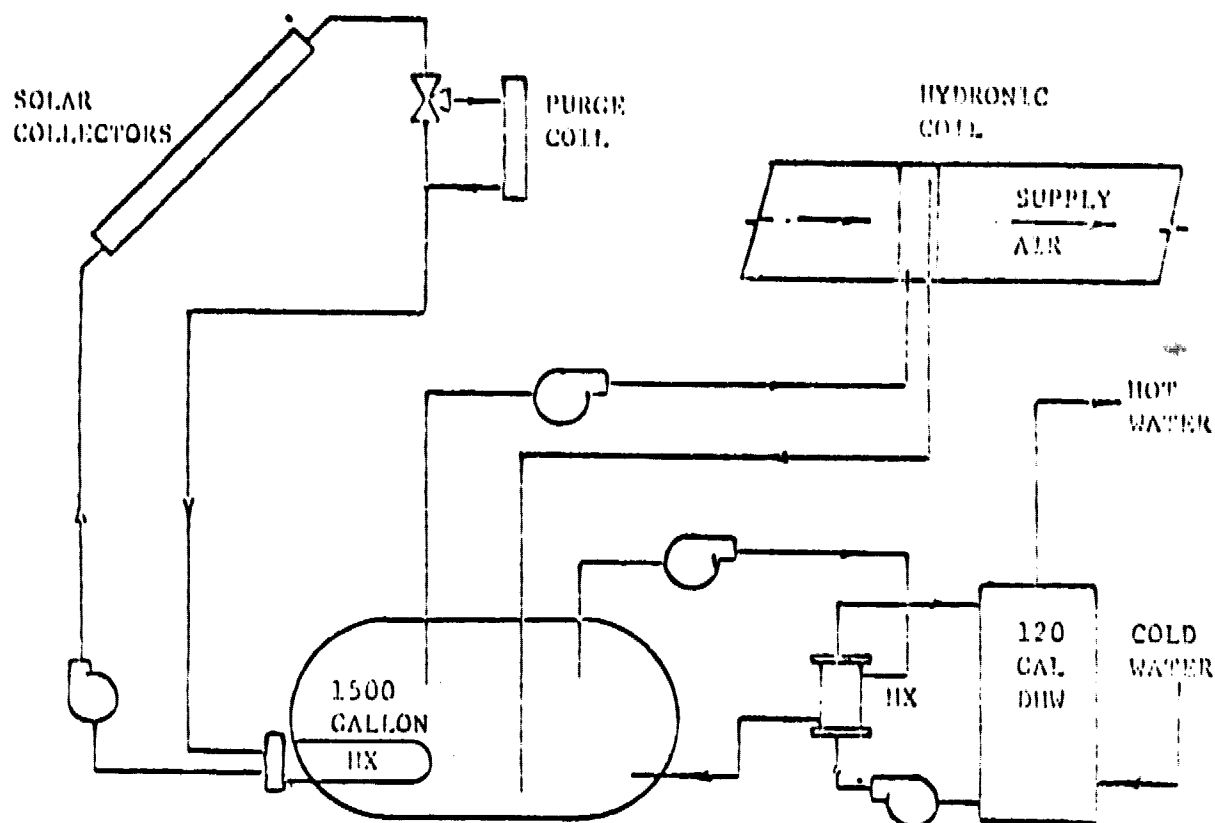


FIGURE 4. FLOW SCHEMATIC OF SYSTEM

Over-temperature protection is supplied by a purge coil in the solar collector piping loop. Flow is diverted through this unit whenever temperature of the returning fluid exceeds 240°F.

Figures 5 and 6 are photographs of the restaurant and various elements of the solar heating system.

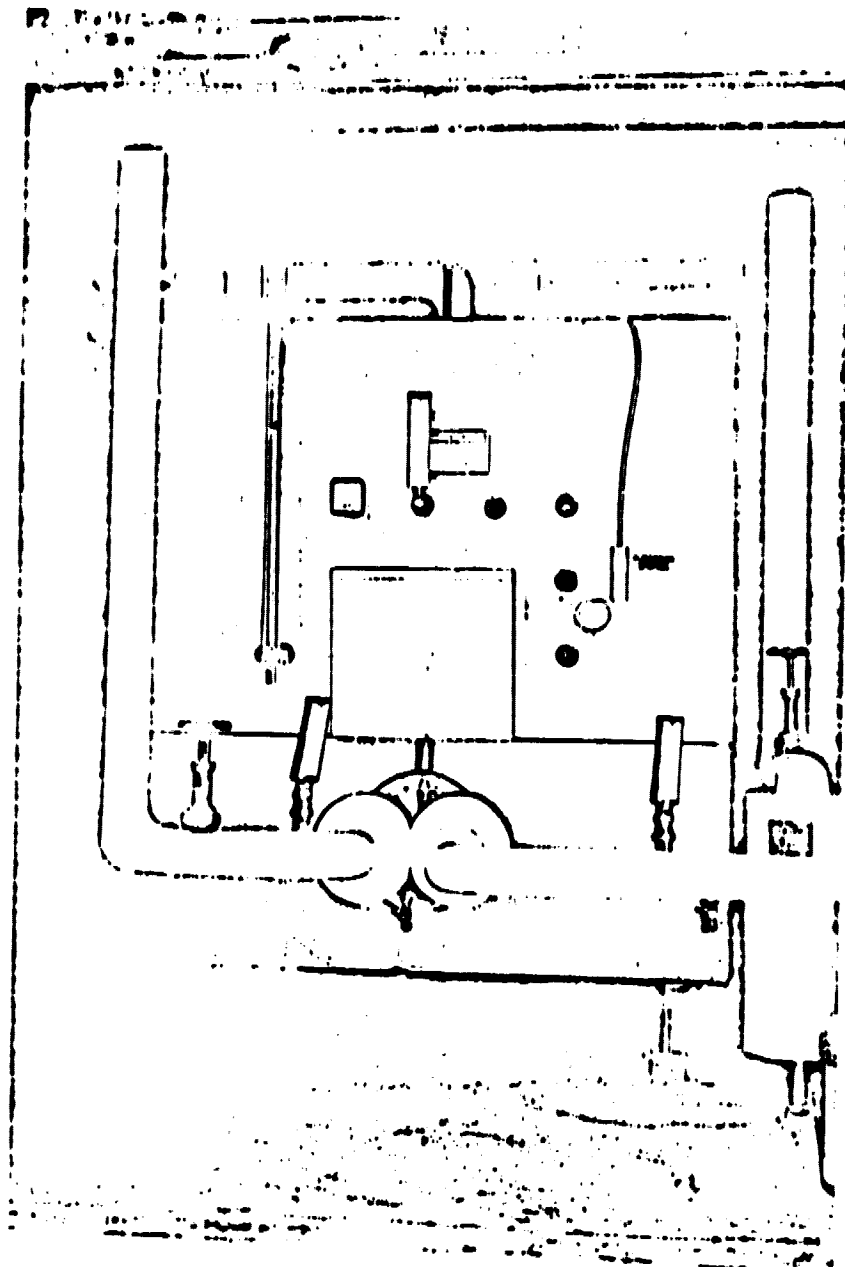
#### PROJECT STATUS

The system installation was virtually completed in December, 1979. System became operational in early 1980 and the final acceptance test was conducted in April, 1980. No major problems have been encountered during the first few months of operation.



VIEW OF COMPLETED RESTAURANT

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SOLAR STORAGE TANK

**PROJECT MILESTONES**

<b>JANUARY 1978:</b>	<b>PROPOSAL SUBMITTED TO DOE BY SHONEY'S SOUTH, INC.</b>
<b>JUNE 1978:</b>	<b>PROJECT SELECTED AS DEMONSTRATION SITE</b>
<b>AUGUST 1978:</b>	<b>COOPERATIVE AGREEMENT NEGOTIATED</b>
<b>SEPTEMBER 1978:</b>	<b>ENGINEERING DESIGN INITIATED</b>
<b>OCTOBER 1978:</b>	<b>FINAL DESIGN REVIEW</b>
<b>JUNE 1979:</b>	<b>GROUND-BREAKING</b>
<b>NOVEMBER 1979:</b>	<b>COLLECTORS INSTALLED</b>
<b>DECEMBER 1979:</b>	<b>INSTALLATION VIRTUALLY COMPLETED</b>
<b>APRIL 1980:</b>	<b>ACCEPTANCE TEST</b>

APPENDIX A

ACCEPTANCE TEST

## ACCEPTANCE TEST PLAN

PROJECT NAME: SHONEY'S SOLAR PROJECT  
PROJECT LOCATION: NORTH LITTLE ROCK, ARKANSAS  
DATE OF TEST: 2/13/80  
INSPECTOR: E.H.PERRY, (ENERGY SOLUTIONS INC)

### I. COLLECTION SUB-SYSTEM

- A. Verify that solar collectors are those called for and that the number of collectors is that called for in the plans and specifications.

COMMENTS: 68 Chamberlain Model 711101  
Single Glazed Collectors

- B. Verify that collector orientation is that called for in the plans.

COMMENTS: Two rows at 35° tilt, 2 rows at 25° tilt  
\_\_\_\_\_

- C. Verify that collector-loop pump is that called for in plans.

COMMENTS: B & C 60-14 T  
\_\_\_\_\_

- D. Verify that pressure relief valves of the rating called for in the plans are installed at each collector array between any shut-off valves.

COMMENTS: OK  
\_\_\_\_\_

- E. Verify that collector fluid is a water/ethylene glycol mixture with a freezing point below -20° F.

COMMENTS: OK  
\_\_\_\_\_

- F. Verify that collector loop can maintain a pressure of 75 psig for 15 minutes with no leaks occurring. If relief valves are removed, care should be taken to insure that solar collectors do not over-heat.

COMMENTS: OK  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

- G. With collector pump operating, adjust "circuit-setter" valves at each of the four collector arrays to provide a flow rate through each array of  $10.0 \pm 1.0$  GPM.

Array #1 (South-most)	Flow Rate =	<u>14</u>	GPM
Array #2	Flow Rate =	<u>14</u>	GPM
Array #3	Flow Rate =	<u>12</u>	GPM
Array #4	Flow Rate =	<u>13</u>	GPM

COMMENTS: Data provided by Jim Hankins of NASA/MSFC  
from tests conducted 4/2/80.  
\_\_\_\_\_  
\_\_\_\_\_

- H. With collector pump operating and with clear skies prevailing, record the system performance via the below table. Fluid temperatures shall be taken with thermometers mounted in the collector supply and return lines as near the collector array as possible. Insolation measurements shall be made with a solar pyranometer in the plane of collector Array #1.





## II. HEAT DISSIPATION SUB-SYSTEM

- A. Verify that purge unit is that called for in the plans or note any exceptions. Verify that unit is installed as shown in the plans.

COMMENTS: McQuay APD - 008BV

Fluid Cooler .

- B. Verify that whenever storage tank temperature exceeds a given (adjustable) set-point that flow returning from the collector array is diverted through purge unit.

COMMENTS: OK

- C. With storage tank temperature above 180° F and with a solar insolation level above 200 BTUH/FT<sup>2</sup> in the collector plane, verify that flow returning to tank heat exchanger via the purge coil is at a lower temperature than flow leaving the tank heat exchanger.

COMMENTS: OK

## III. STORAGE SUB-SYSTEM

- A. Verify that main storage tank and all related hardware are as specified in the plans. Verify that tank carries an ASME seal.

COMMENTS: Thermopak 1500 gallon

- B. Verify that tank drain valve and sight gage are operative.

COMMENTS: OK  
\_\_\_\_\_  
\_\_\_\_\_

- C. Verify that tank is equipped with a pressure relief valve as shown in the plans.

COMMENTS: OK  
\_\_\_\_\_  
\_\_\_\_\_

IV. SPACE HEATING SUB-SYSTEM

- A. Verify that space heating coil(s) and pump are as shown as plans or note exceptions.

COMMENTS: Two Coils  
\_\_\_\_\_  
\_\_\_\_\_

- B. Through use of the "circuit-setter" valve in the loop, adjust the flow rate in the space heating loop to  $20.0 \pm 1.0$  GPM.

COMMENTS: Valves OK  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

- C. Determine the performance of the system by measuring the space heating coil inlet temperature, outlet temperature and flow rate.

Coil Inlet Temp. ( $T_1$ )	=	<u>124</u>	Op
Coil Outlet Temp. ( $T_2$ )	=	<u>108</u>	Op
Flow Rate (GPM)	=	<u>-</u>	GPM
Heat Delivery = $500 \times (T_1 - T_2) \times \text{GPM}$	=	<u>-</u>	BTUH

COMMENTS: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

V. DOMESTIC HOT WATER SUB-SYSTEM

- A. Verify that domestic water heating system is installed in accordance with the plans or note any exceptions.

COMMENTS: A. O. Smith series 730  
119-gallon, 54 kW external B & G H-X  
Model BHST-520-C60  
   
   
 

- B. Verify that a tempering valve has been installed to prevent excessive delivery temperatures or note any exception.

COMMENTS: OK  
   
   
   
 

- C. Verify that a minimum of two heat exchanger walls separate the potable domestic water from any non-potable fluids in the system.

COMMENTS: Primary solar H-X in 1500 gallon tank.  
DHW shell-and-tube H-X (item "A" above)  
   
 

VI. CONTROLS SUB-SYSTEM

- A. Verify that controls are installed as indicated on the plans or note any exceptions.

COMMENTS: Collector loop controller is Honeywell

- B. Verify that solar collector pump starts whenever the collector temperature exceeds the main storage temperature by 20° F and remains on until this temperature difference falls to less than 3° F.

COMMENTS: OK  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
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- C. Verify that whenever main storage tank temperature exceeds a given set point (nominally 240° F) and collector pump is on, the flow returning from the collectors is diverted through the purge coil via the two-position motorized valve and that purge coil fan is simultaneously activated. Verify that this condition prevails until tank temperature drops to at least 2° below the given set point.

COMMENTS: OK  
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- D. Verify that whenever the building's thermostat calls for space heat and the main storage tank temperature is above a given set-point

(nominally 100°F), the space heating pump is activated and that the air-handling unit is activated simultaneously.

COMMENTS: OK  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
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- E. Verify that if building thermostat calls for heat and storage tank temperature is below a given set-point (nominally 100°F) that electric resistance heating elements and the air-handling unit are activated.

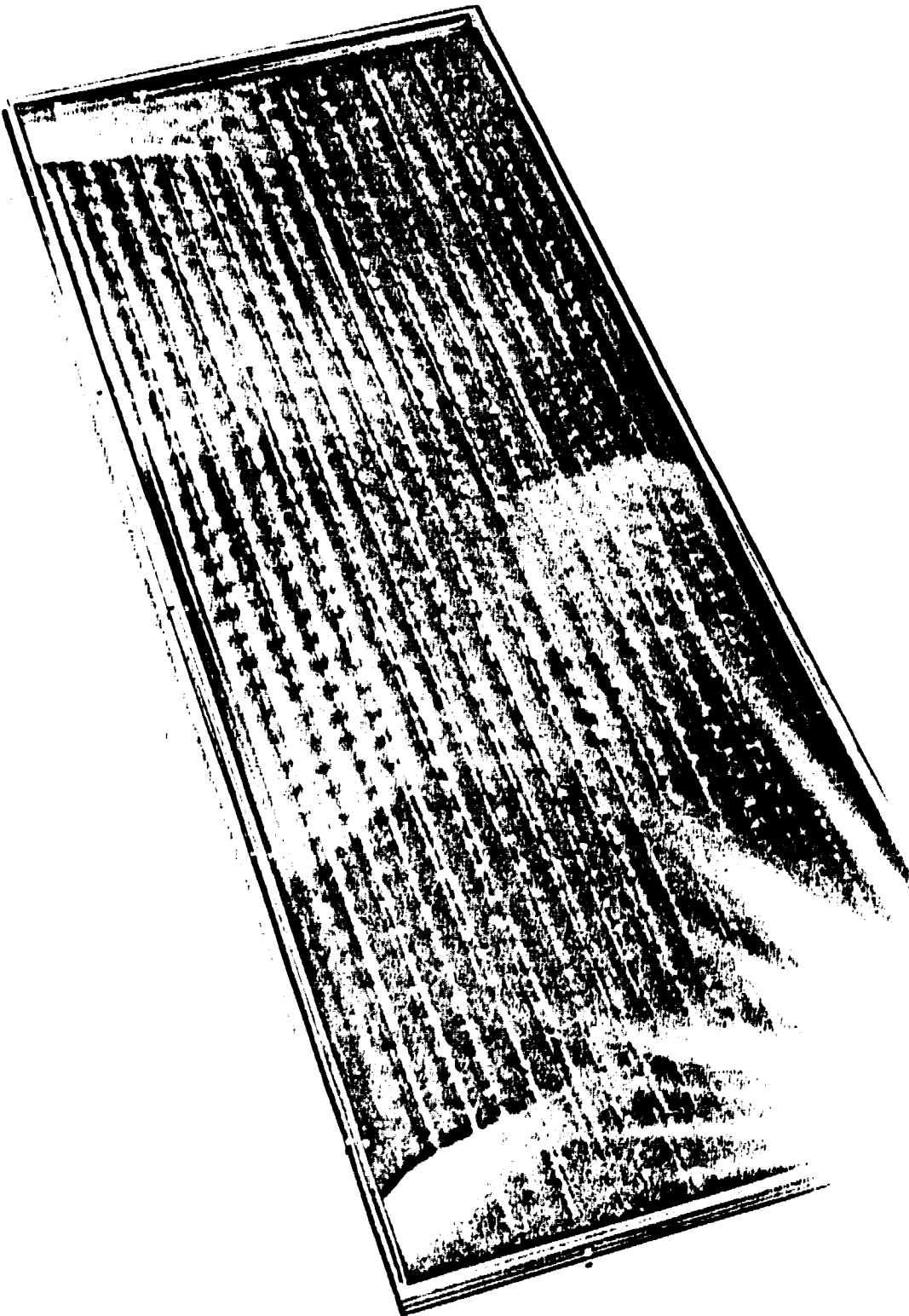
COMMENTS: OK  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

- F. Verify that the domestic hot water pump(s) is (are) activated whenever the domestic hot water temperature is below 180°F and at least 10°F below the temperature of the main storage tank. Pump(s) shall stay on until domestic hot water temperature reaches either 180°F or within 3°F of the main storage temperature.

COMMENTS: OK  
\_\_\_\_\_  
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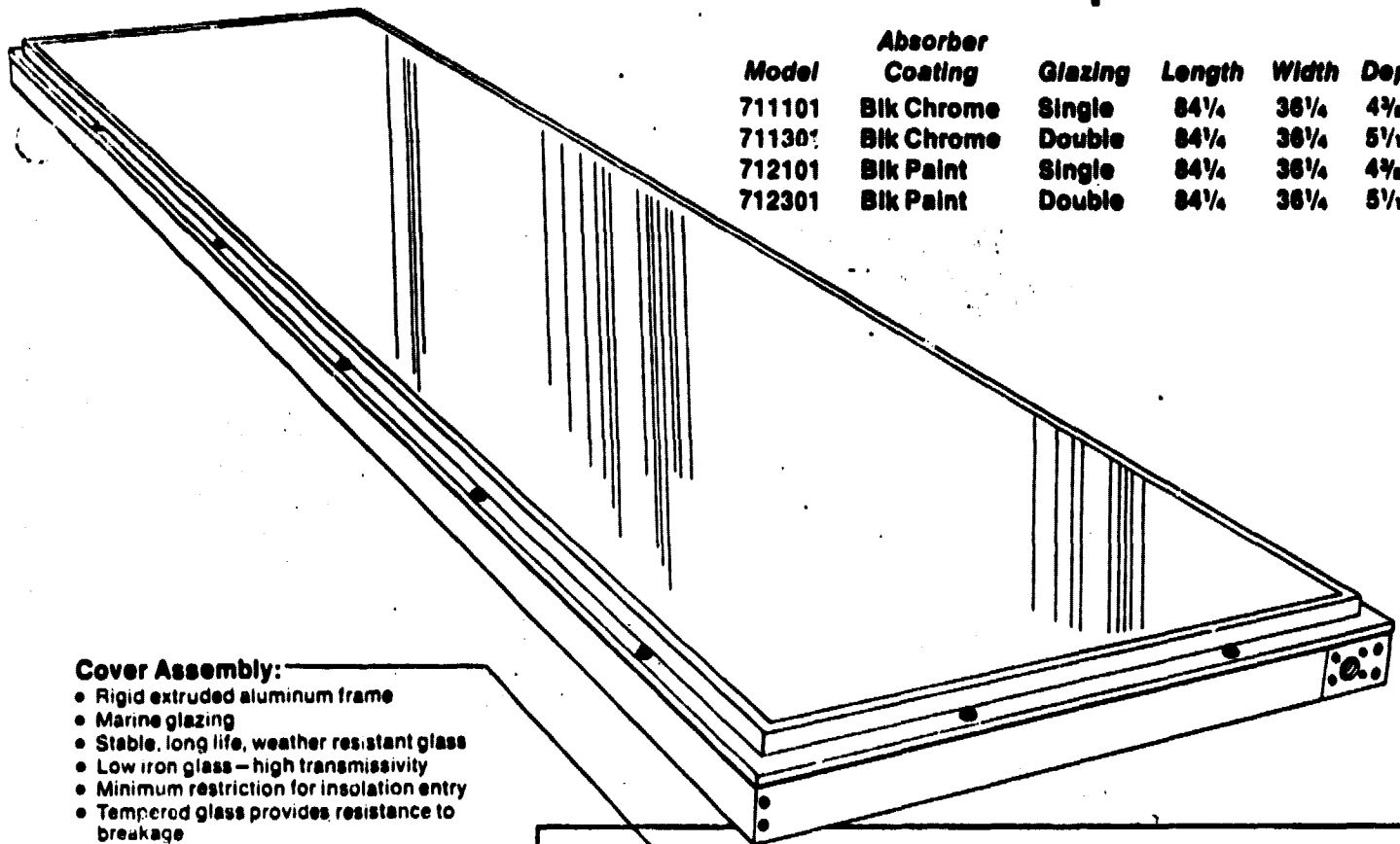
**APPENDIX B**

**EQUIPMENT LITERATURE**



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# Features and Specifications:



Model	Absorber Coating	Glazing	Length	Width	Depth
711101	Blk Chrome	Single	84 1/4	36 1/4	4 1/8
711301	Blk Chrome	Double	84 1/4	36 1/4	5 1/8
712101	Blk Paint	Single	84 1/4	36 1/4	4 1/8
712301	Blk Paint	Double	84 1/4	36 1/4	5 1/8

## Cover Assembly:

- Rigid extruded aluminum frame
- Marine glazing
- Stable, long life, weather resistant glass
- Low iron glass — high transmissivity
- Minimum restriction for insolation entry
- Tempered glass provides resistance to breakage
- Serviceable in the field

## Cover Gasket:

- Provides seal between cover and box
- Thermally isolates absorber cavity from metal parts exposed to atmosphere
- Resilient, long life material

## Steel Absorber Plate:

- Maximum wetted surface
- Minimum flow resistance
- Rugged steel construction
- Pressure tested
- Selection of coatings available

## High Temperature Insulating Strip:

- Insulates absorber plate from frame

## Absorber Support:

- Rigid support bracket welded to side of box

## Mounting:

- Two 1/2" weld nuts each corner
- Rigid
- Easy to adapt to any support
- No projections — will not become damaged in shipment

## Piping Connection:

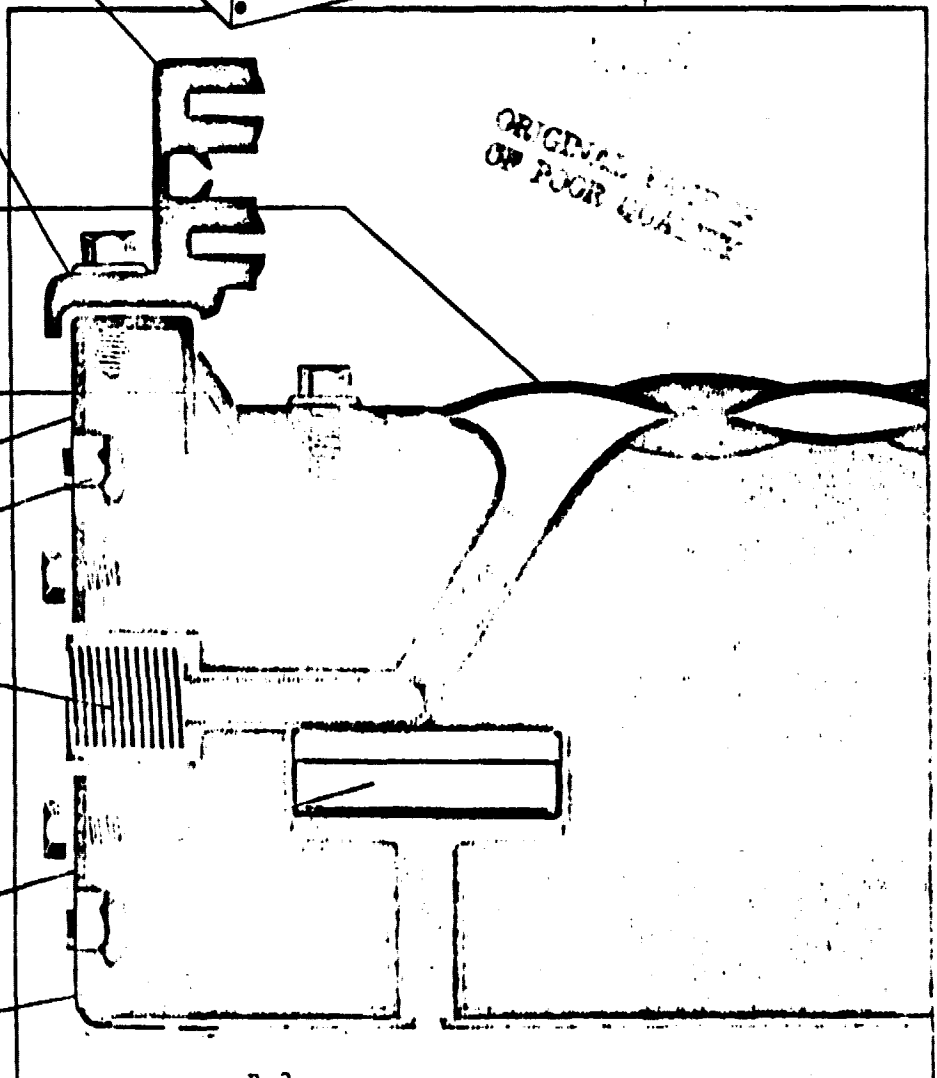
- 1/2" Female iron pipe thread
- Flush mounted — avoids shipping damage
- Uses standard pipe fittings
- Thermally insulated from box
- Ruggedly attached to box — allows for heavy handed plumbers
- Isolates absorber plate from external piping movement

## Desiccant:

- Controls moisture in absorber cavity
- Minimizes condensation on glass
- Regenerated by absorber plate heat

## Insulation:

- High temperature Fiberglass insulation
- Maximum insulation with minimum volume





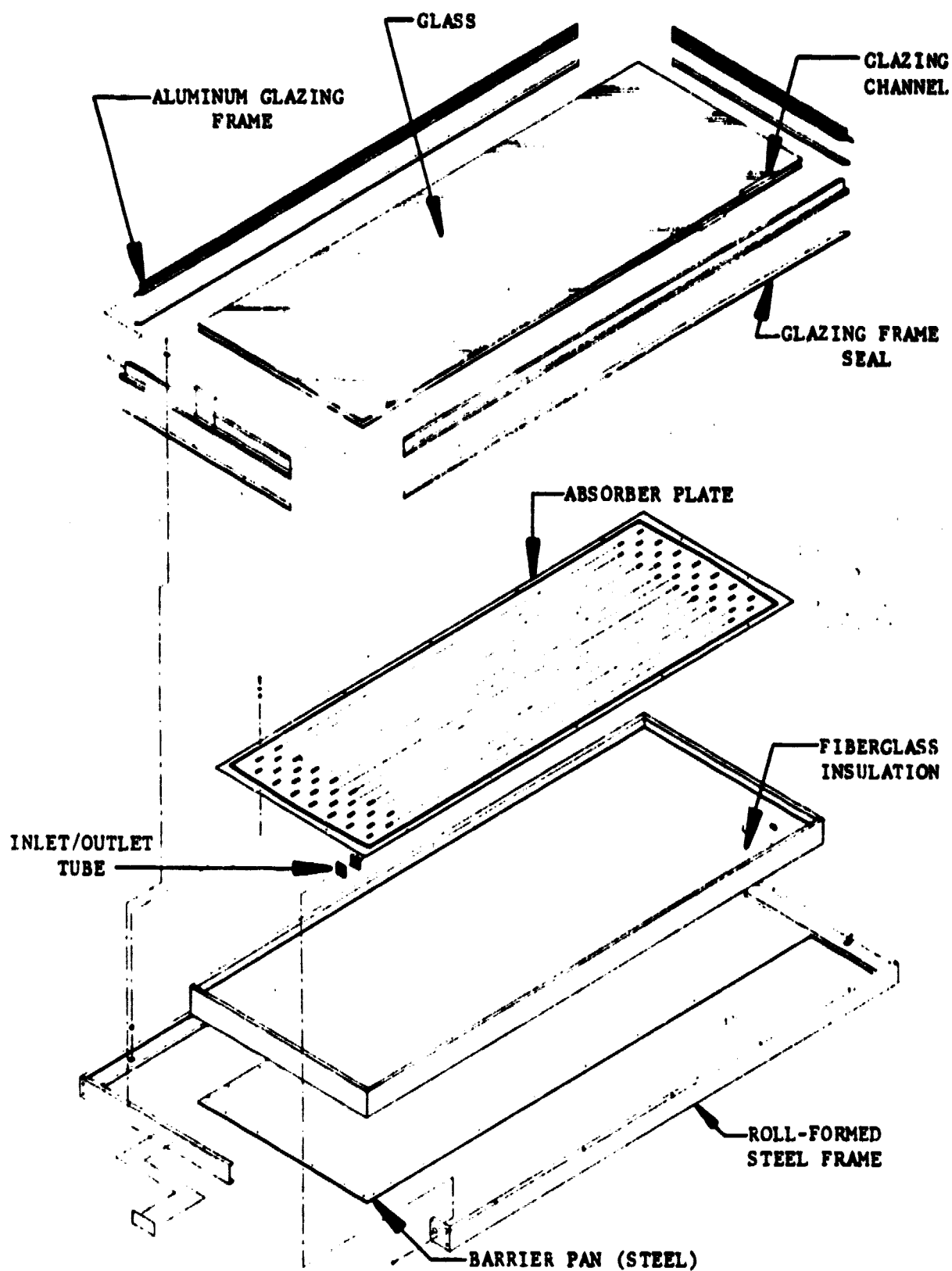


FIGURE 1. EXPLODED VIEW OF SOLAR COLLECTOR

- Absorber Plate - Two 20 gauge mild steel sheets seam welded together around the perimeter and stitch welded on 1-3/4 inch centers over the entire plate. The assembly is then pressure expanded to form a flow passage between the plates resulting in a very durable, low cost absorber with excellent heat transfer characteristics due to the 90% wetted area.
- Black Chrome Selective Coating - Solar absorptivity = 0.94, infrared emissivity = 0.12, or
- Black Paint Absorber Surface - Solar absorptivity = 0.97, infrared emissivity = 0.92.
- Two Lite 1/8-Inch Thick Low Iron Tempered Glass Cover in Extruded Aluminum Frame - Outer cover tempered glass, inner cover tempered glass. Total solar energy transmission of each lite is 90% (.90 x .90 = .81 = total transmissivity), or
- One Lite 1/8-Inch Thick Low Iron Tempered Glass Cover in Extruded Aluminum Frame - Total solar energy transmission of 90%.
- Roll-Formed, 18-Gauge Galvanized Steel Frame - Roll-formed steel can be shaped at low cost at high production rates and in a large variety of shapes. Galvanizing reduces corrosion problems.
- 1,000°F Rated Face-Temperature Fiberglass - The fiberglass insulation is formed from a 5-inch thick blanket compressed to a nominal 3-inch thickness. The insulation has an effective thermal resistance factor of approximately  $R = 10$ . The material has a very low binder content, which eliminates outgassing problems sometimes encountered in fiberglass insulations. The side insulation thickness was sized to result in the greatest overall collector efficiency. The insulation is building code approved.
- Desiccant - A passive drying system regenerated by the heat of the absorber plate. The desiccant used is silica gel. The desiccant system reduces moisture condensation in the collector.
- Inlet/Outlet Steel Tubes - Angled from the absorber plate to the collector frame. All expansion/contraction of the absorber is taken up in the flexing of the tube internally to the collector. The tubes terminate flush to the box in a 1/2-inch NPT female connection.

#### TRANSPARENT COVER:

Materials and Selection Rationale. The transparent cover material is composed of one or two lites of 1/8-inch tempered glass with low iron content. Tempered glass was selected for its ability to withstand wind and snow loads,

induced thermal stresses, and its resistance to degradation with temperature and time. Low iron glass was chosen because of its high transmissivity and cost-effectiveness.

Optical Properties. Tests conducted over a seven-month sample period showed that the total solar energy transmissivity of the glass is  $90\% \pm 0.5\%$ . The transmission losses are 8% reflection and 2% absorption. The glass emissivity is 0.88; infrared reflectance is 4% and IR absorptance is 0.96.

Physical Properties. The thermal and physical properties of the glass are those common to standard tempered glass. The coefficient of thermal expansion is about  $5 \times 10^{-6}$  in./in./°F; the modulus of elasticity is 10,000,000 psi. The tensile strength is 30,000 psi. Tests on a 3 ft by 7 ft sheet of glass show it will withstand loads up to 50 psf. The glass meets standards set forth by FHA, AAMA, and the Safety Glazing Code.

#### ABSORBER PLATE COATING:

Two absorptive coatings are offered on the collector models described in this document.

Material and Selection Rationale. Six of the most promising absorber coatings were tested, and the two most resistant to thermal degradation and offering the highest cost-effectiveness were selected. The black paint was superior at low average plate temperature, and the black chrome was superior at high average plate temperature.

Black Chrome. The coating consists of black chrome over dull nickel. The solar absorptivity is a minimum of 0.94, and the infrared emissivity is 0.12 maximum. The coating maintains its optical properties to 750°F. Black chrome is not subject to photo degradation, and nickel-chromium coatings offer excellent corrosion protection.

Black Paint. The paint is comprised of a two-step, two part process. The base coat is an epoxy material which provides corrosion protection and acts as the primer for the black surface. The black paint outer surface is specially formulated for large temperature excursions and long lifetime. The paint has been exposed to the environmental elements for extended time periods without property degradation. The resulting absorptivity and emissivity of the paint is 0.97 and 0.92, respectively.

#### ABSORBER PLATE:

Materials and Selection Rationale. The absorber plate is made of mild carbon steel seam welded and pressure expanded. This results in a wetted surface of over 90%. The selection of steel was based on its superior corrosion properties, as compared to aluminum, and its cost advantage over copper. In addition, Chamberlain's years of fabricating steel products makes the eventual inclusion of the manufacturing of steel absorber plates a natural expansion of the Corporation's product line.

Fabrication Procedures/Processes. The steel absorber plates are produced as follows: Two sheets 20-gauge (.0359-inch thick) carbon steel material are placed flat against each other, with one of the sheets having inlet/outlet tube "stubs" brazed in place. A continuous seam weld is made around the perimeter of the plates, closing the system. Beginning a short distance (approximately three inches) from either end of the smaller span, intermittent seam welds approximately 0.5-inch long are applied to within about three inches of the other end, which results in a "quilted" pattern, or "stitch" weld. The dimensions are approximate, because each end has a slight taper to the stitch weld for drainage purposes. Following completion of the lengthwise stitch welding at 1-23/32 center-to-center spacing, hydraulic pressure is applied to expand the metal, forming the flow passages with nominal 0.090-inch inside height on each passage.

Physical Properties and Dimensions. Fluid pressures up to 75 psi can be sustained without deformation or degradation of the absorber plate. A manifold at each end of the plate ensures proper flow distribution in the flow passages. Typical passage height between welds is 0.090 inch.

Thermal Properties. The absorber plate design results in over 90% wetted area. This results in excellent heat transfer characteristics with a heat removal factor  $F_R$  of about 0.97 and a collector efficiency factor  $F'$  of about 0.99.

Manifold Design. The manifold design allows for even flow distribution. Tests in Chamberlain's solar laboratory have shown that the temperature distribution across the collector at any longitudinal position is essentially constant. The manifold is designed to allow the collector to be drained completely at typical installation angles.

Inlet/Outlet Tube Design. The inlet/outlet tubes exit the absorber plate in the center bottom of each end and exit the collector housing at the sides of the lower and upper ends. The tubes are made of 0.375-inch O.D. by 0.035-inch wall, low carbon steel, dead soft annealed. They terminate flush to the collector housing in a 1/2-inch NPT female fitting. This arrangement allows the thermal expansion/contraction of the absorber plate to be absorbed in the flexing of the tubing internal to the collector box.

#### INSULATION:

Materials and Selection Rationale. The insulation used for back and edge thermal protection is a low binder content insulation rated for 1,000°F face temperatures. A 5-inch thick blanket is compressed to the 3-inch dimensioned cavity behind the absorber plate. The edge insulation is formed from a 1-inch thick blanket compressed to 0.875 inch. Transportation tests have proven that insulation movement, or "packing", does not occur. The overall R factor on the backside is approximately 10.

Density. Nominal density is 1.05 lb/ft<sup>3</sup>.

Weights of Collectors. Collector model numbers 711301 and 712301 weigh 190 pounds dry (9 pounds/square foot); model numbers 711101 and 712101 weigh 160 pounds (7.6 pounds/square foot); model numbers 711302 and 712302 weigh 225 pounds; model numbers 711102 and 712102 weigh 190 pounds. Liquid capacity is approximately 0.6 gallon.

Method of Support. The collector is supported on each of the four corners and attached by means of 5/16-18UNC bolts (two at each corner).

Provision for Uplift of Covers and Collectors. The entire cover assembly can be removed from the collector by removing the retaining screws. The cover can be removed without removing the collector from the array or disturbing adjacent collectors. Lifting the collector should be accomplished by lifting from all four corners with an appropriate spreader, but the collector may be lifted by hand without incurring damage.

Collector Ganging Configurations. Collectors may be positioned in arrays in any manner as long as provisions are made to ensure that pressure drop requirements are within acceptable limits, that there is equal flow to all collectors, and that no localized boiling occurs. Most large installations will require analysis of the flow distribution.

Thermal Expansion with Ganged Collectors. All expansion occurs within the collector box; therefore, the only expansion which must be considered in the ganged collector is that of the connecting piping.

Differential Expansion Between Roof and Collector. The collector box is thermally isolated from the absorber and will not experience sufficient thermal expansion to cause differential expansion problems.

Maintenance of Weather-Tight Seal. Experience with the collectors has demonstrated that no leakage occurs. This is a result of Chamberlain's years of experience in manufacturing insulating doors and windows. The various parts of the collector housing are weatherproofed with a standard architectural sealant.

## B. INSTANTANEOUS EFFICIENCY CURVES

The instantaneous efficiency (Figures 3 through 6) has been normalized to account for the varying insolation rates and ambient temperatures. The curves thus represent efficiency versus  $AT/I$ , where

$AT$  = Average fluid temperature minus ambient temperature

$I$  = Instantaneous insolation

This form is useful in describing collector parameters for systems analysis computer programs such as TRNSYS and FCHART; it is also the form recommended by NBS in their document NBSIR 74-635 and that form required in the ASHRAE Standard 93-77. In accordance with ASHRAE 93-77, the collector efficiency is defined as the ratio of energy collected to the energy falling on the gross area of the collector. The curves presented in Figures 3 through 6 have been substantiated by test data gathered using production collectors in the Chamberlain R&D Solar Laboratory. This laboratory is instrumented in compliance with NBSIR 74-635 and ASHRAE 93-77.

Using the simplified form of the definition of efficiency to describe the linear variation of efficiency versus  $AT/I$ ,

$$\eta = \tau\alpha - U_L (AT/I),$$

the resulting equations for the thermal performance of the Chamberlain flat plate collectors are shown below. The equations given are accurate for both the 3 x 7 and 3 x 8 collector models.

Model 711101 and 711102 (Single Glazed, Black Chrome)

$$\eta = .80 - .85 AT/I$$

Model 711301 and 711302 (Double Glazed, Black Chrome)

$$\eta = .72 - .58 AT/I$$

Model 712101 and 701102 (Single Glazed, Black Paint)

$$\eta = .79 - 1.16 AT/I$$

Model 712301 and 712302 (Double Glazed, Black Paint)

$$\eta = .73 - .80 AT/I$$

SINGLE GLAZED BLACK CHROME  
 MODEL NOS. 711101, 711102  
 EFFICIENCY BASED ON GROSS AREA

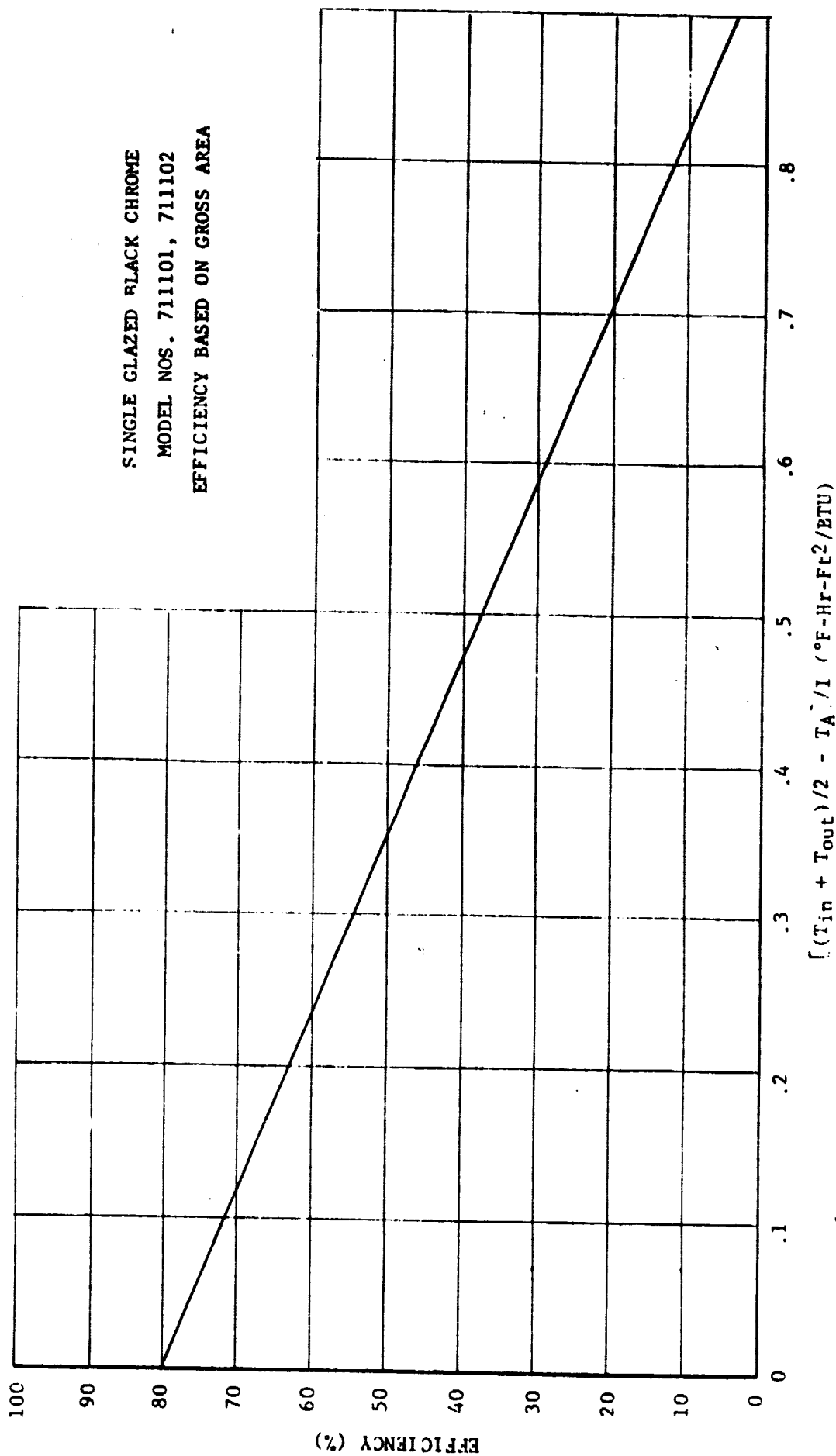


Figure 3. Instantaneous Efficiency

### C. PERFORMANCE CERTIFICATION TESTS

Independent performance certification tests on the Chamberlain Manufacturing Corporation flat plate solar collectors were conducted during the period 20 November 1976 to 5 February 1977. Tests were conducted on the single and double cover black chrome models by Desert Sunshine Exposure Tests, Inc., located in Phoenix, Arizona. The tests were performed in accordance with DSET Specification 75SE2, Method 75SE2.3 (NBS proposed method TN899), utilizing an altazimuth sun-tracking (ENI) mount which maintained the collectors at normal incidence to the sun over the test period. The collector net aperture area was used for the performance reference area.

Tabulated results of these tests, as provided by Desert Sunshine Exposure Tests, Inc., are attached, in addition to the instantaneous efficiency graphs. In the tabulated values, where integrated values were reported, the mean value for the integral is given in parentheses.

The data were analyzed employing a second order least squares polynomial which yielded the following equations describing the efficiency of the collector in terms of the fluid parameter  $(\bar{T}_f - T_a)/q_i$ , where

$\bar{T}_f$  = average fluid temperature

$T_a$  = ambient temperature

$q_i$  = incident solar radiation

#### Single Cover-Black Chrome

$$\eta = 0.841 - 0.532 [(\bar{T}_f - T_a)/q_i] - 0.505 [(\bar{T}_f - T_a)/q_i]^2$$

#### Double Cover-Black Chrome

$$\eta = 0.772 - 0.678 [(\bar{T}_f - T_a)/q_i] + 0.006 [(\bar{T}_f - T_a)/q_i]^2$$

Although second order analysis of the data is more consistent with the thermodynamic considerations of collector performance, it is common practice to express collector performance equations in linear form for convenience and ease of analysis. In this respect, the data were also analyzed using a least squares linear regression, resulting in the following linear equations describing the efficiency as a function of the fluid parameter.

#### Single Cover-Black Chrome

$$\eta = 0.865 - 0.814 [(\bar{T}_f - T_a)/q_i]$$

#### Double Cover-Black Chrome

$$\eta = 0.771 - 0.674 [(\bar{T}_f - T_a)/q_i]$$





DESERT SUNSHINE EXPOSURE TESTS, INC.

Box 185, Black Canyon Stage  
Phoenix, Arizona 85020

COMPANY: CHAMBERLAIN MANUFACTURING CORP.  
REFERENCE NO.: PO B-52337  
DSET NO.: 17003S  
REPORT NO.: 76S1111A

DATE: November 20, 1976  
COLLECTOR: Mod. #711101, Ser. 01048  
GLAZING: Single Glass<sup>2</sup>  
APERTURE AREA: 19.12 ft<sup>2</sup>

TEST METHOD: DSET 75SE2.3 (NBS/ENI)

(SINGLE COVER - BLACK CHROME)

t, solar	1108	1113	1118	1123	1328
$\bar{h}$ (lb/hr)	274.74	274.69	272.72	273.69	283.12
$\int T_i$ (°F)	233.1	233.0	232.4	232.9	174.0
$\int T_o$ (°F)	242.8	243.0	242.5	242.4	187.2
$T_p$ (°F)	-	-	-	-	-
$T_p$ (°F)	-	-	-	-	-
$T_p$ (°F)	-	-	-	-	-
$\int T_a$ (°F)	70.6	69.2	68.7	70.0	73.8
Wind Velocity	S 2	S 4	S 8	W 2	SW 8
Air Over Collector (fpm)	90	300	200	210	480
$C_p$ (BTU/lb.°F)	1.01142	1.01142	1.01136	1.01139	1.00279
$\int q_i$ (BTU/FT <sup>2</sup> .hr)	325.02	326.39	327.42	327.60	322.80
$q_i$ , % Diffuse	13.51	13.86	13.80	13.66	14.50
Tilt Angle	53.4	53.1	52.9	52.6	56.0
Incidence Angle	0°	0°	0°	0°	0°
Azimuth Angle	15.3	13.9	12.4	11.0	-25.1
$P_{in}$ (psi)	28.8	29.0	29.3	29.8	16.2
$\Delta P$ (psi)	4.2	4.1	3.8	3.8	4.2
$\int \Delta T$ (°F)	9.7	10.0	10.1	9.6	13.1
$T_f$ (°F)	237.9	238.0	237.5	237.7	180.6
$T_p$ (°F)	-	-	-	-	-
$T_f - T_a$ (°F)	167.3	168.7	168.8	167.6	106.8
$T_p - T_a$ (°F)	-	-	-	-	-
$T_i - T_a$ (°F)	162.5	163.8	163.7	162.9	100.2
$(T_f - T_a)/q_i$ *	0.515	0.517	0.515	0.512	0.331
$(T_i - T_a)/q_i$ *	0.500	0.502	0.500	0.497	0.310
$(T_p - T_a)/q_i$ *	-	-	-	-	-
$\eta_{q_i}$ **	-	-	-	-	-
Efficiency, $\eta$	0.433	0.445	0.445	0.423	0.603

\*°F/BTU/FT<sup>2</sup>.hr

\*\*BTU/FT<sup>2</sup>.hr

Page 1 of 4

Mean values in parentheses.



DESERT SUNSHINE EXPOSURE TESTS, INC.

Box 185, Black Canyon Stage  
Phoenix, Arizona 85020

COMPANY: CHAMBERLAIN MANUFACTURING CORP.  
REFERENCE NO.: PO B-52337  
DSET NO.: 17003S  
REPORT NO.: 76S111A

DATE: November 20, 1976  
COLLECTOR: Mod. #711101, Ser. 01048  
GLAZING: Single Glass  
APERTURE AREA: 19.12 ft<sup>2</sup>

TEST METHOD: DSET 75SE2.3 (NBS/ENI)

(SINGLE COVER - BLACK CHROME)

t, solar	1333	1338	1343	1448	1453
$\dot{m}$ (lb/hr)	279.23	281.22	281.20	285.92	283.92
$\int T_i$ (°F)	174.1	174.4	174.2	122.5	122.5
$\int T_o$ (°F)	186.9	187.2	187.1	137.0	136.8
$T_p$ (°F)	-	-	-	-	-
$T_p$ (°F)	-	-	-	-	-
$T_p$ (°F)	-	-	-	-	-
$\int T_a$ (°F)	72.9	73.7	73.2	73.3	73.4
Wind Velocity	S 7	SW 9	S 7	S 3	W 2
Air Over Collector (fpm)	260	680	510	320	420
$C_p$ (BTU/lb.°F)	1.00278	1.00281	1.00279	0.99888	0.99887
$\int q_i$ (BTU/ft <sup>2</sup> .hr)	321.23	319.88	318.74	293.36	289.66
$q_i$ * Diffuse	14.06	14.61	14.86	16.69	16.78
Tilt Angle	56.5	56.9	57.5	65.6	66.4
Incidence Angle	0°	0°	0°	0°	0°
Azimuth Angle	-26.4	-27.7	-29.0	-43.7	-44.7
$P_{in}$ (psi)	16.2	16.1	16.1	17.2	17.0
$\Delta P$ (psi)	4.1	4.1	4.1	4.9	4.7
$\int \Delta T$ (°F)	12.9	12.8	12.9	14.5	14.2
$T_f$ (°F)	180.5	180.8	180.7	129.8	129.6
$T_p$ (°F)	-	-	-	-	-
$T_f - T_a$ (°F)	107.6	107.1	107.5	56.4	56.2
$T_p - T_a$ (°F)	-	-	-	-	-
$T_i - T_a$ (°F)	101.2	100.7	101.0	49.2	49.1
$(T_f - T_a)/q_i$ *	0.335	0.335	0.337	0.192	0.194
$(T_i - T_a)/q_i$ *	0.315	0.315	0.317	0.168	0.170
$(T_p - T_a)/q_i$ *	-	-	-	-	-
$\eta_{q_i}$ **	-	-	-	-	-
Efficiency, $\eta$	0.583	0.591	0.595	0.741	0.728

\*°F/BTU/ft<sup>2</sup>.hr

\*\*BTU/ft<sup>2</sup>.hr

Page 2 of 4

Mean values in parentheses.



DESERT SUNSHINE EXPOSURE TESTS, INC.

Box 185, Black Canyon Stage  
Phoenix, Arizona 85020

COMPANY: CHAMBERLAIN MANUFACTURING CORP.  
REFERENCE NO.: PO B-52337  
DSET NO.: 17003S  
REPORT NO.: 76S1111A

DATE: November 21, 1976  
COLLECTOR: Mod. #711101, Ser. 0104  
GLAZING: Single Glass  
APERTURE AREA: 19.12 ft<sup>2</sup>

TEST METHOD: DSET 75SE2.3 (NBS/ENI)

(SINGLE COVER - BLACK CHROME)

t, solar	1138	1143	1148	1153	
$\bar{h}$ (lb/hr)	289.79	290.81	295.11	289.72	
$\int T_i$ (°F)	76.8	76.9	77.0	77.1	
$\int T_o$ (°F)	94.4	94.4	94.5	94.7	
$T_p$ (°F)	-	-	-	-	
$T_p$ (°F)	-	-	-	-	
$T_p$ (°F)	-	-	-	-	
$\int T_a$ (°F)	73.1	72.4	72.5	72.8	
Wind Velocity	S 2	S 4	S 8	S 5	
Air Over Collector (fpm)	30	250	500	500	
$C_p$ (BTU/lb.°F)	0.99802	0.99802	0.99802	0.99802	
$\int q_i$ (BTU/FT <sup>2</sup> .hr)	326.26	327.05	328.33	328.87	
$q_i$ , % Diffuse	14.73	13.36	15.07	15.09	
Tilt Angle	52.2	52.0	52.0	51.9	
Incidence Angle	0°	0°	0°	0°	
Azimuth Angle	6.6	5.1	3.6	2.1	
$P_{in}$ (psi)	18.9	18.7	18.7	18.8	
$\Delta P$ (psi)	4.9	4.7	4.6	4.7	
$\int \Delta T$ (°F)	17.6	17.5	17.5	17.6	
$\bar{T}_f$ (°F)	85.6	85.7	85.7	85.9	
$T_p$ (°F)	-	-	-	-	
$T_f - T_a$ (°F)	12.6	13.3	13.2	13.1	
$T_p - T_a$ (°F)	-	-	-	-	
$T_f - T_a$ (°F)	3.7	4.5	4.5	4.3	
$(T_f - T_a)/q_i$	0.038	0.041	0.040	0.040	
$(T_f - T_a)/q_i$	0.011	0.014	0.014	0.013	
$(T_p - T_a)/q_i$	-	-	-	-	
$\eta_{q_i}$	-	-	-	-	
Efficiency, $\eta$	0.814	0.812	0.821	0.810	

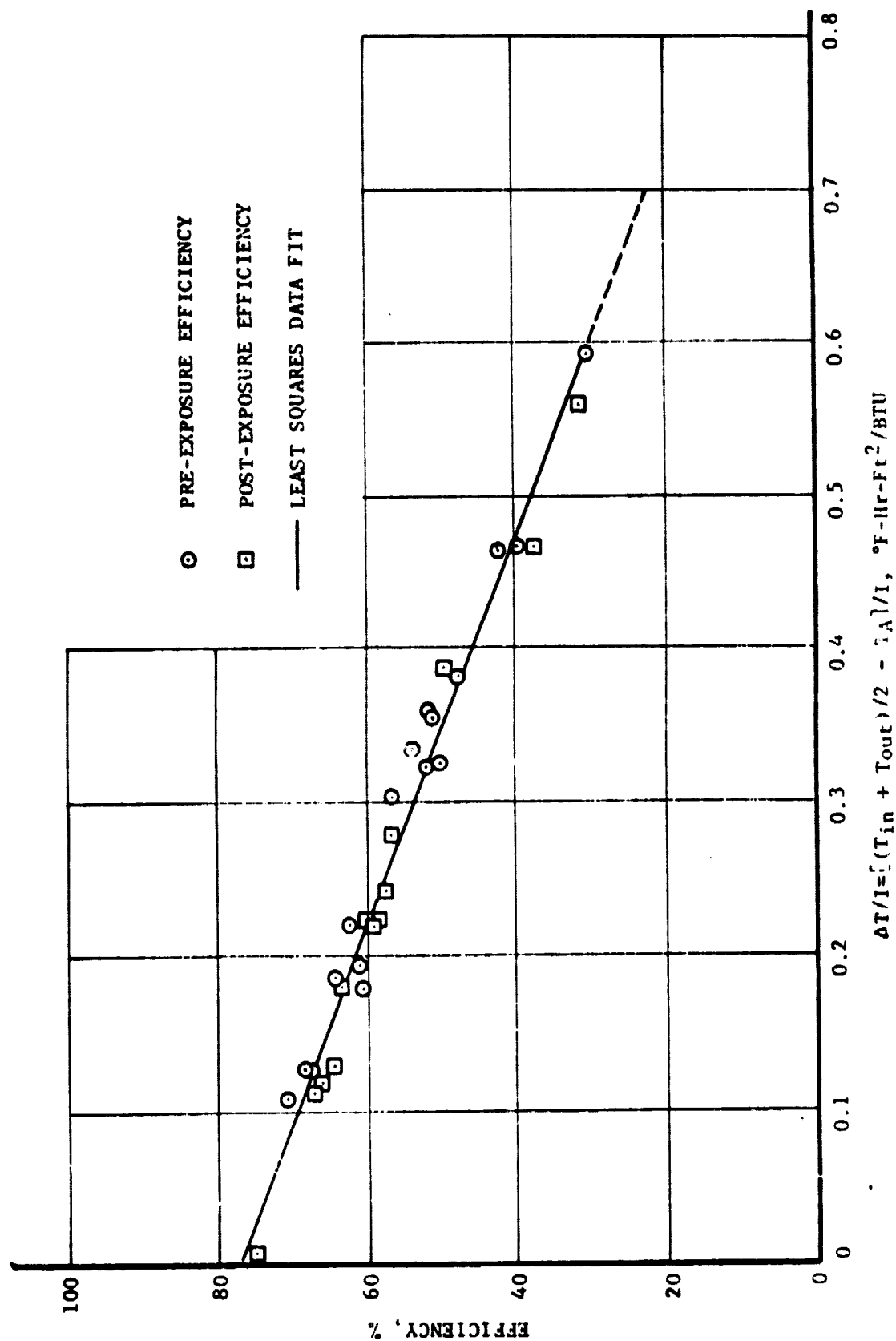
\*\*F/BTU/FT<sup>2</sup>.hr

\*\*BTU/FT<sup>2</sup>.hr

Page 4 of 4

Mean values in parentheses.

CHAMBERLAIN MANUFACTURING CORPORATION  
SINGLE COVER/BLACK CHROME  
MODEL NO. 711101

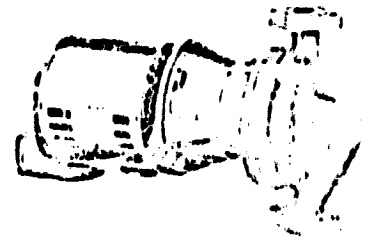
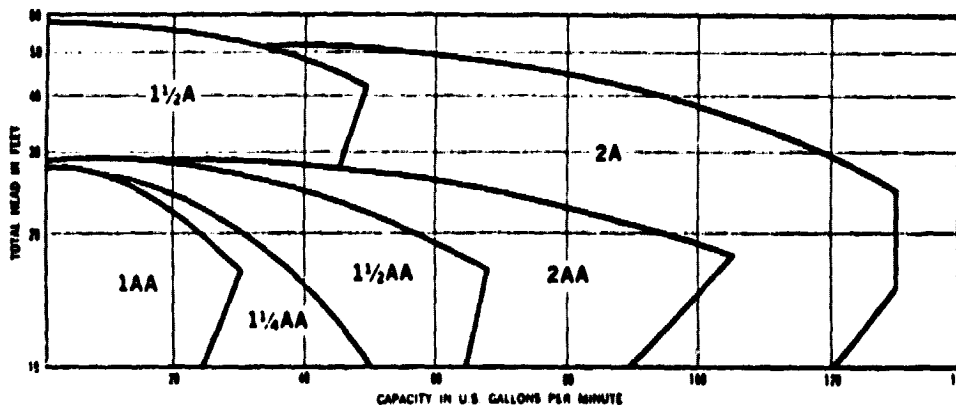


BELL & GOSSETT

CURVE BOOKLET

B-160  
REVISION 6

Selection Chart



# SERIES 60

In-line Mounted Centrifugal Pumps

## PERFORMANCE CURVES

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## SERIES "60" CENTRIFUGAL PUMPS

### DIMENSIONS

FIG. 1 AA SIZES

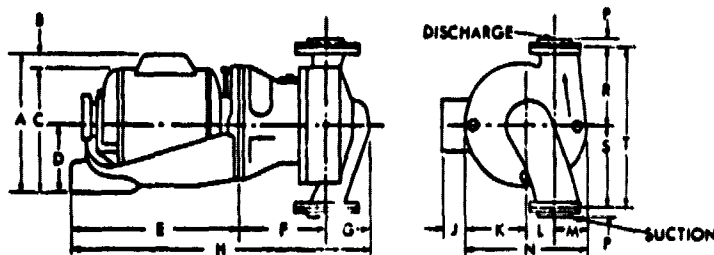
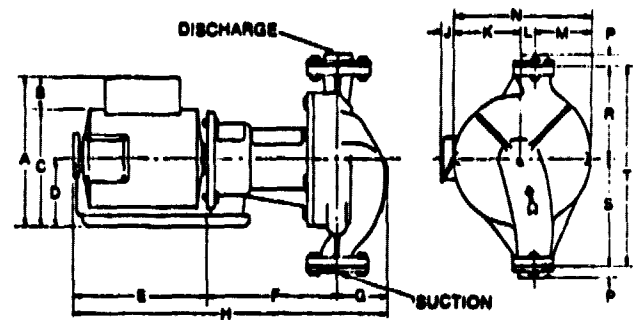


FIG. 2 A SIZES



ALL SINGLE PHASE MOTORS INCLUDE BUILT-IN THERMAL OVERLOAD PROTECTORS.  
BRONZE FITTED CONSTRUCTION†—COMPANION FLANGES FURNISHED FOR SUCTION AND DISCHARGE.  
MOTORS—OPEN DRIPPROOF ENCLOSURE. SINGLE PHASE—UNIT NO. ENDING IN "S" 115/230 VOLT • 60 CYCLE 1 PHASE 1750 RPM.  
THREE PHASE—UNIT NO. ENDING IN "T" 200-230/460 VOLT 60 CYCLE 3 PHASE 1750 RPM. MAXIMUM WORKING PRESSURE 175 PSI

MODEL NO.	PUMP SIZE	SUCTION & DISCHARGE SIZE INS. NPT	MOTOR H.P.	PHASE	DIMENSIONS—IN INCHES																
					A	B	C	D	E	F	G	H	J	K	L	M	N	P	R	S	T
† 60-11S *	1½AA	1½	¼	1	7½	—	7½	4½	10	5½	3½	19½	—	3½	1½	2½	7½	¾	5	6	11
60-11T	1½AA	1½	¼	3	7½	—	7½	4½	9½	5½	3½	19	—	3½	1½	2½	7½	¾	5	6	11
† 60-13S	1½AA	1½	½	1	9½	2½	7½	4½	11½	6	3½	21½	—	3½	1½	2½	7½	¾	5	6½	11½
† 60-13T	1½AA	1½	½	3	7½	—	7½	4½	11	6	3½	20½	—	3½	1½	2½	7½	¾	5	6½	11½
† 60-14S	2AA	2	¾	1	9½	2½	7½	4½	12	6½	3½	21½	—	3½	1½	2½	8	1½	5	6½	11½
† 60-14T	2AA	2	¾	3	7½	—	7½	4½	11½	6½	3½	21½	—	3½	1½	2½	8	1½	5	6½	11½
60-15S	1½A	1½	½	1	9½	2½	7½	4½	11½	9½	3½	24½	—	4½	1	3½	9½	¾	6½	7	13½
60-15T	1½A	1½	½	3	7½	—	7½	4½	11	9½	3½	24	—	4½	1	3½	9½	¾	6½	7	13½
60-16S	1½A	1½	¾	1	9½	2½	7½	4½	12	9½	3½	25	—	4½	1	3½	9½	¾	6½	7	13½
60-16T	1½A	1½	¾	3	7½	—	7½	4½	11½	9½	3½	24½	—	4½	1	3½	9½	¾	6½	7	13½
60-17S	1½A	1½	1	1	10½	2½	8½	4½	9½	9½	3½	22½	¾	4½	1	3½	9½	¾	6½	7	13½
60-17T **	1½A	1½	1	3	8½	—	8½	4½	10	9½	3½	23	¾	4½	1	3½	9½	¾	6½	7	13½
60-19S	2A	2	1	1	10½	2½	8½	4½	9½	9½	3½	23	¾	4½	1	4½	9½	1½	6½	7½	14
60-19T **	2A	2	1	3	8½	—	8½	4½	10	9½	3½	23½	¾	4½	1	4½	9½	1½	6½	7½	14
60-20S	2A	2	1½	1	10½	2½	8½	4½	10½	9½	3½	23½	¾	4½	1	4½	9½	1½	6½	7½	14
60-20T **	2A	2	1½	3	8½	—	8½	4½	10½	9½	3½	24½	¾	4½	1	4½	9½	1½	6½	7½	14
60-21T **	2A	2"	2	3	8½	—	8½	4½	11½	9½	3½	24½	¾	4½	1	4½	9½	1½	6½	7½	14

(See Reverse Side for Capacity Chart)

\*¼ H.P. 115 VOLT ONLY.

\*\*200-208 VOLT OR 230/460 VOLT — PLEASE SPECIFY.

†UNITS SO MARKED ALSO AVAILABLE IN ALL BRONZE CONSTRUCTION.

# 1 1/2" AA **SERIES 60** PERFORMANCE CURVES

## PERFORMANCE CHARACTERISTIC CURVE

FOR 1 1/2" AA CENTRIFUGAL PUMP FIG NO SERIES 60

SPEED 1750 R P M

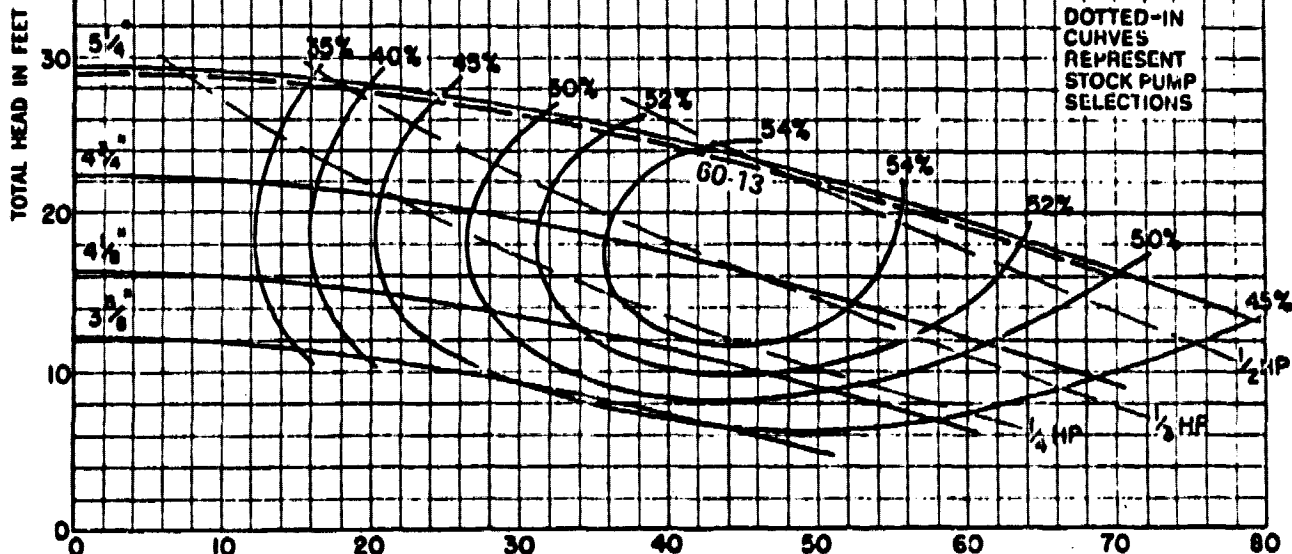
CURVES BASED ON SHOP TEST USING CLEAR COLD WATER AT A TEMPERATURE OF NOT OVER 85°F. PERFORMANCE IS GUARANTEED AT INDICATED OPERATING POINT ONLY. HORSEPOWER CURVES DO NOT INCLUDE MOTOR SERVICE FACTOR.

APPROVED *Russ*

DATE 5-26-61

**1 1/2" AA**  
1750 R.P.M.

Impellers are trimmed in 1/8" increments to supply required capacity. Responsibility for final impeller sizing remains with IIT Bell & Gossett.



## PERFORMANCE CHARACTERISTIC CURVE

FOR 2" AA CENTRIFUGAL PUMP FIG NO SERIES 60

SPEED 1750 R P M

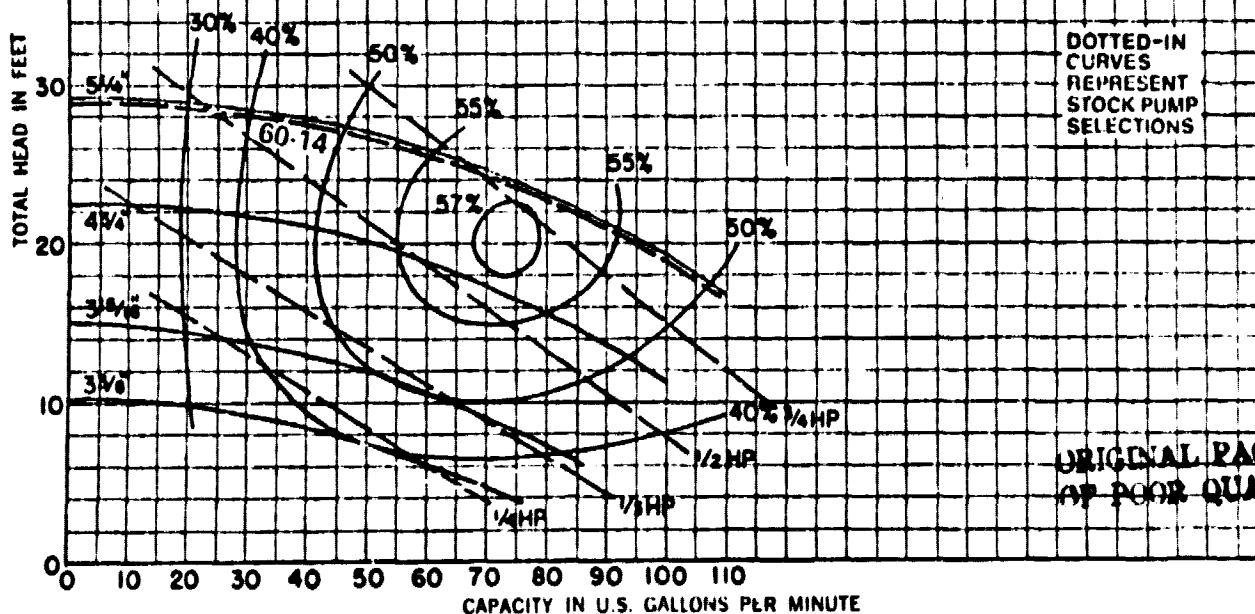
CURVES BASED ON SHOP TEST USING CLEAR COLD WATER AT A TEMPERATURE OF NOT OVER 85°F. PERFORMANCE IS GUARANTEED AT INDICATED OPERATING POINT ONLY. HORSEPOWER CURVES DO NOT INCLUDE MOTOR SERVICE FACTOR.

APPROVED *Russ*

DATE 2/21/61

**2" AA**  
1750 R.P.M.

Impellers are trimmed in 1/8" increments to supply required capacity. Responsibility for final impeller sizing remains with IIT Bell & Gossett.



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DIMENSIONS ON PAGE 7

Dimensions subject to change without notice. Do not use for construction purposes.

## SERIES "60" CENTRIFUGAL PUMPS

### DIMENSIONS

FIG. 1 AA SIZES

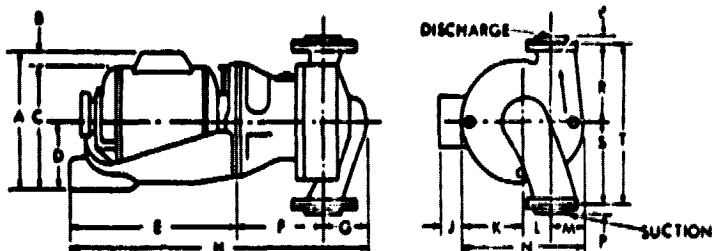
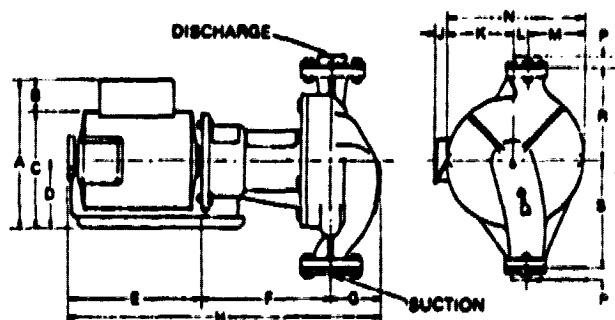


FIG. 2 A SIZES



MAXIMUM WORKING PRESSURE 175 PSI

PUMP SIZE	SUCTION AND DISCHARGE SIZE—INCHES NPT	PUMP DIMENSIONS—INCHES									
		F	G	K	L	M	N	P	R	S	T
1AA	1	5 $\frac{1}{4}$	3 $\frac{3}{4}$	3	1 $\frac{1}{4}$	1 $\frac{1}{4}$	6 $\frac{1}{4}$	$\frac{3}{4}$	5	6	11
1 $\frac{1}{4}$ AA	1 $\frac{1}{4}$	5 $\frac{1}{4}$	3 $\frac{3}{4}$	3 $\frac{3}{4}$	1 $\frac{1}{4}$	2 $\frac{1}{4}$	7 $\frac{1}{4}$	$\frac{3}{4}$	5	6	11
1 $\frac{1}{2}$ AA	1 $\frac{1}{2}$	6	3 $\frac{3}{4}$	3 $\frac{3}{4}$	1 $\frac{1}{4}$	2 $\frac{1}{4}$	7 $\frac{1}{4}$	$\frac{3}{4}$	5	6 $\frac{1}{4}$	11 $\frac{1}{4}$
2AA	2	6 $\frac{1}{4}$	3 $\frac{3}{4}$	3 $\frac{3}{4}$	1 $\frac{1}{4}$	2 $\frac{1}{4}$	8	$\frac{3}{4}$	5	6 $\frac{1}{4}$	11 $\frac{1}{4}$
1 $\frac{1}{2}$ A	1 $\frac{1}{2}$	9 $\frac{1}{4}$	3 $\frac{3}{4}$	4 $\frac{1}{4}$	1	3 $\frac{1}{4}$	9 $\frac{1}{4}$	$\frac{3}{4}$	6 $\frac{1}{4}$	7	13 $\frac{1}{4}$
2A	2	9 $\frac{1}{4}$	3 $\frac{3}{4}$	4 $\frac{1}{4}$	1	4 $\frac{1}{4}$	9 $\frac{1}{4}$	$\frac{3}{4}$	6 $\frac{1}{4}$	7 $\frac{1}{4}$	14

ALL MOTORS 1750 RPM							
MOTOR SIZE		MOTOR DIMENSIONS—INCHES					
H.P.	PHASE	A	B	C	D	E	J
$\frac{1}{4}$	1	7 $\frac{1}{4}$	—	7 $\frac{1}{4}$	4 $\frac{1}{4}$	10	—
$\frac{1}{4}$	3	7 $\frac{1}{4}$	—	7 $\frac{1}{4}$	4 $\frac{1}{4}$	9 $\frac{1}{4}$	—
$\frac{1}{2}$	1	9 $\frac{1}{4}$	2 $\frac{1}{4}$	7 $\frac{1}{4}$	4 $\frac{1}{4}$	11	—
$\frac{1}{2}$	3	7 $\frac{1}{4}$	—	7 $\frac{1}{4}$	4 $\frac{1}{4}$	11	—
$\frac{1}{2}$	1	9 $\frac{1}{4}$	2 $\frac{1}{4}$	7 $\frac{1}{4}$	4 $\frac{1}{4}$	11 $\frac{1}{4}$	—
$\frac{1}{2}$	3	7 $\frac{1}{4}$	—	7 $\frac{1}{4}$	4 $\frac{1}{4}$	11	—

ALL MOTORS 1750 RPM							
MOTOR SIZE		MOTOR DIMENSIONS—INCHES					
H.P.	PHASE	A	B	C	D	E	J
$\frac{1}{4}$	1	9 $\frac{1}{4}$	2 $\frac{1}{4}$	7 $\frac{1}{4}$	4 $\frac{1}{4}$	12	—
$\frac{1}{4}$	3	7 $\frac{1}{4}$	—	7 $\frac{1}{4}$	4 $\frac{1}{4}$	11 $\frac{1}{4}$	—
1	1	10 $\frac{1}{4}$	2 $\frac{1}{4}$	8 $\frac{1}{4}$	4 $\frac{1}{4}$	9 $\frac{1}{4}$	$\frac{3}{4}$
1	3	8 $\frac{1}{4}$	—	8 $\frac{1}{4}$	4 $\frac{1}{4}$	10	$\frac{3}{4}$
1 $\frac{1}{2}$	1	10 $\frac{1}{4}$	2 $\frac{1}{4}$	8 $\frac{1}{4}$	4 $\frac{1}{4}$	10 $\frac{1}{4}$	$\frac{3}{4}$
1 $\frac{1}{2}$	3	8 $\frac{1}{4}$	—	8 $\frac{1}{4}$	4 $\frac{1}{4}$	10 $\frac{1}{4}$	$\frac{3}{4}$
2	3	8 $\frac{1}{4}$	—	8 $\frac{1}{4}$	4 $\frac{1}{4}$	11 $\frac{1}{4}$	$\frac{3}{4}$



# B&G Booster Pumps

B&G Booster Pumps represent a long process of design refinement for performance improvement—yet the basic principles of the first unit produced are still present in today's models.

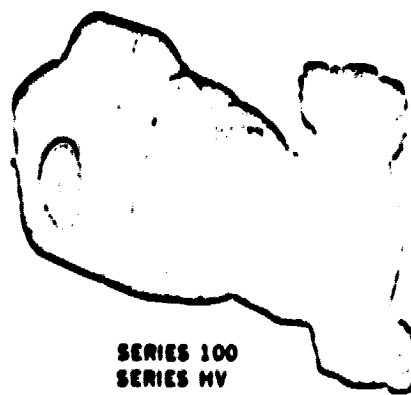
It is still a horizontal pump—a design originally selected because it had numerous efficiency and installation advantages. The watertight seal, which made possible an oil circulating lubrication system, was pioneered by B&G. Today, while the same in principle, it has been improved in design and materials used.

Sound engineering, supported by precision manufacturing, are the reasons the B&G Booster Pump shows such a remarkable record for efficiency, dependability and long life. To date more than 8,000,000 B&G Booster Pumps have been installed. Ample evidence that their quality remains unchallenged.

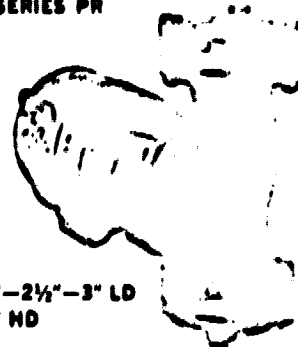
Iron or bronze-fitted pumps *should not be used* for circulating service water. Continual pumping of fresh water, which contains acids and corrosive substances in varying amounts, frequently causes rapid deterioration of such pumps.

Bronze non-ferrous Booster Pumps are available for circulating service water through buildings and for energy saving controlled water circulation between a heater and hotwater storage tank.

The "Remite" Seal in bronze B&G Booster Pumps is a further warranty of long lasting performance. The extremely hard, corrosion-resistant material of which the seal is made and its ingenious method of assembly assure long service under severest operating conditions. See page 4 for pump capacity chart.



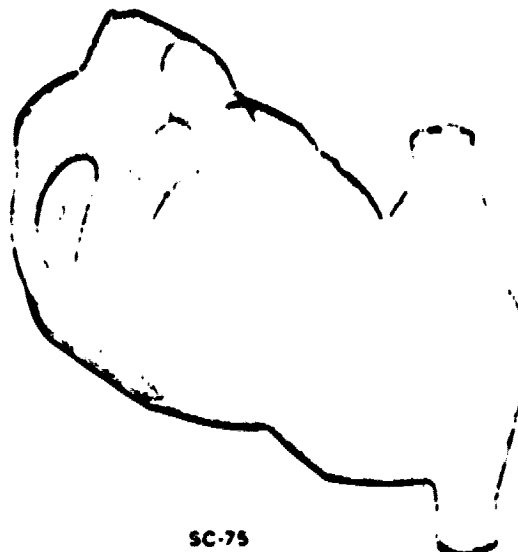
SERIES 100  
SERIES HV  
SERIES 1½  
SERIES PR



2"-2½"-3" LD  
3" HD



PD-35  
PD-37  
PD-38  
PD-40



SC-75

# IRON AND BRONZE BOOSTER PUMP

Performance characteristics are based on using 1 1/4" or 1 1/2" flanges. When using 3/4" or 1" flanges performance will be slightly reduced.

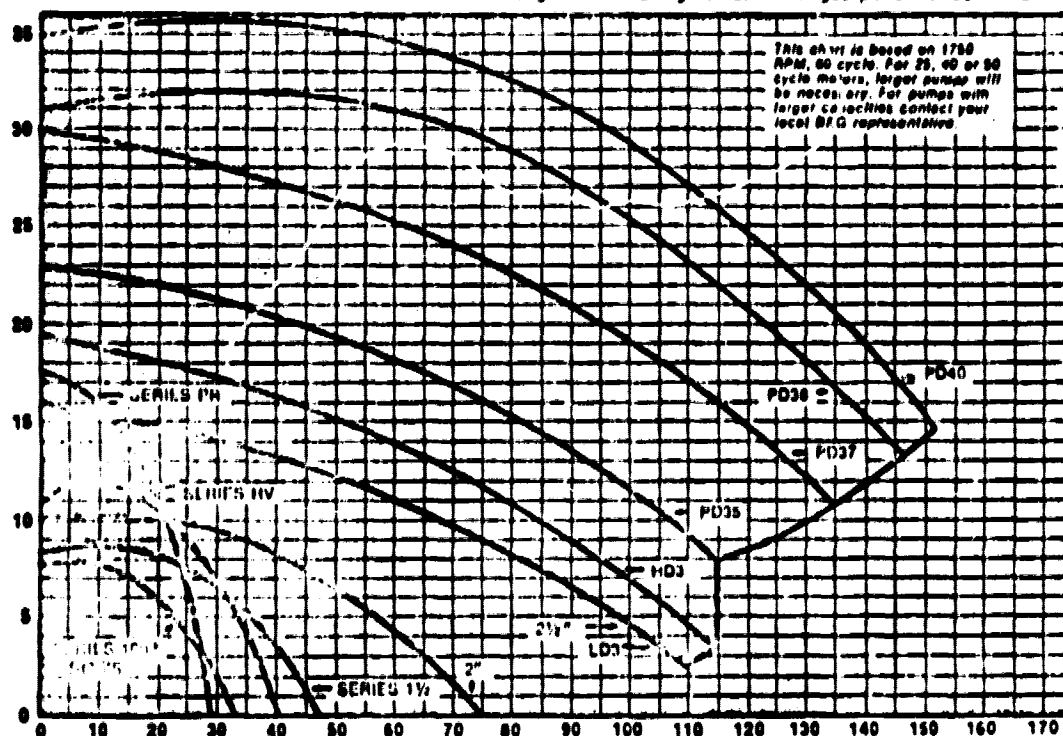
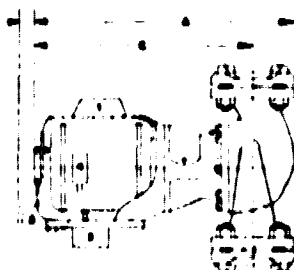


FIG. 1-10-1

MODEL NO.	FLANGE SIZE, NPT INCHES (specify size)	STANDARD 60 CYCLE MOTOR CHARACTERISTICS (special motors available on request)			DIMENSIONS IN INCHES (open drip-proof)					APPROX. SHPG. WT. LBS.	
		HP	V	VOLTAFF	A	B	C	D	E	IRON BODY	BRONZE
Series 100	1/4"	1/12	1	115 With Built-in Overload Protection	15	6 1/4"	12 1/4"	1 1/4"	—	21	21
	1 & 1 1/4"							1 1/2"	—		
	1 1/2"							1 3/4"	—		
SC-75	Sweal	1/4	1	115 With Built-in Overload Protection	16 1/4"	8 1/2"	13 1/4"	1 1/4"	—	38	39
	1 & 1 1/4"							1 1/2"	—		
	1 1/2"							1 3/4"	—		
Series PR	1 & 1 1/4"	3/4	1	115 With Built-in Overload Protection	16 1/4"	8 1/2"	13 1/4"	1 1/4"	—	28	28
	1 1/2"							1 1/2"	—		
	1 3/4"							1 3/4"	—		
Series HV	1 & 1 1/4"	1	1	115 With Built-in Overload Protection	16 1/4"	8 1/2"	13 1/4"	1 1/4"	—	30	30
	1 1/2"							1 1/2"	—		
	1 3/4"							1 3/4"	—		
Series 1 1/2	1 & 1 1/4"	2	1	115 With Built-in Overload Protection	17 1/4"	10	14 1/4"	1 1/4"	—	40	40
	1 1/2"							1 1/2"	—		
	1 3/4"							1 3/4"	—		
LD3	2 1/4"	1 1/2	1	115 With Built-in Overload Protection	18 1/4"	12	15 1/4"	1 1/4"	—	59	62
	2 1/2"							1 1/2"	—		
	2 3/4"							1 3/4"	—		
HD3	2 1/4"	1 1/2	1	115 With Built-in Overload Protection	18 1/4"	12	15 1/4"	1 1/4"	—	58	63
	2 1/2"							1 1/2"	—		
	2 3/4"							1 3/4"	—		
PD35-S	1 & 1 1/4"	1	1	115/230	20 1/4"	14 1/2"	19 1/4"	1 1/4"	—	78	84
	1 1/2"			208/230/460	20 1/4"			1 1/2"	—		
	1 3/4"			115/230	21 1/4"			1 3/4"	—		
PD35-Y	1 & 1 1/4"	1	1	208/230/460	20 1/4"	14 1/2"	19 1/4"	1 1/4"	—	80	82
	1 1/2"			115/230	21 1/4"			1 1/2"	—		
	1 3/4"			208/230/460	20 1/4"			1 3/4"	—		
PD37-S	1 & 1 1/4"	1	1	115/230	24	14 1/2"	19 1/4"	1 1/4"	—	128	140
	1 1/2"			208/230/460	24 1/4"			1 1/2"	—		
	1 3/4"			115/230	24 1/4"			1 3/4"	—		
PD37-Y	1 & 1 1/4"	1	1	208/230/460	24 1/4"	14 1/2"	19 1/4"	1 1/4"	—	125	135
	1 1/2"			115/230	24 1/4"			1 1/2"	—		
	1 3/4"			208/230/460	25 1/4"			1 3/4"	—		
PD38-S	1 & 1 1/4"	1 1/2	1	115/230	24 1/4"	14 1/2"	19 1/4"	1 1/4"	—	132	140
	1 1/2"			208/230/460	24 1/4"			1 1/2"	—		
	1 3/4"			115/230	24 1/4"			1 3/4"	—		
PD40-S	1 & 1 1/4"	1 1/2	1	208/230/460	25 1/4"	14 1/2"	19 1/4"	1 1/4"	—	135	142
	1 1/2"			115/230	25 1/4"			1 1/2"	—		
	1 3/4"			208/230/460	25 1/4"			1 3/4"	—		



ELECTRICAL BOX ARRANGEMENT FOR BOOSTER PUMPS WITH BELL & GOSSETT MANUFACTURED MOTORS

Model Number	#1	#2	#3	#4
Series 100 and SC-75	All Std.			
Series PR, HV, 1 1/2" and 2"	115 Volt	Other 115	30	
2 1/2", LD3 and HD3		10	30	
PD35 and PD37			All	
PD38 and PD40				All

MAXIMUM WORKING PRESSURE 125 PSI

MAXIMUM OPERATING TEMPERATURE

Standard Seal:

225°F continuous

250°F intermittent on closed systems using modulated temperature control proper pump location and system pressurization

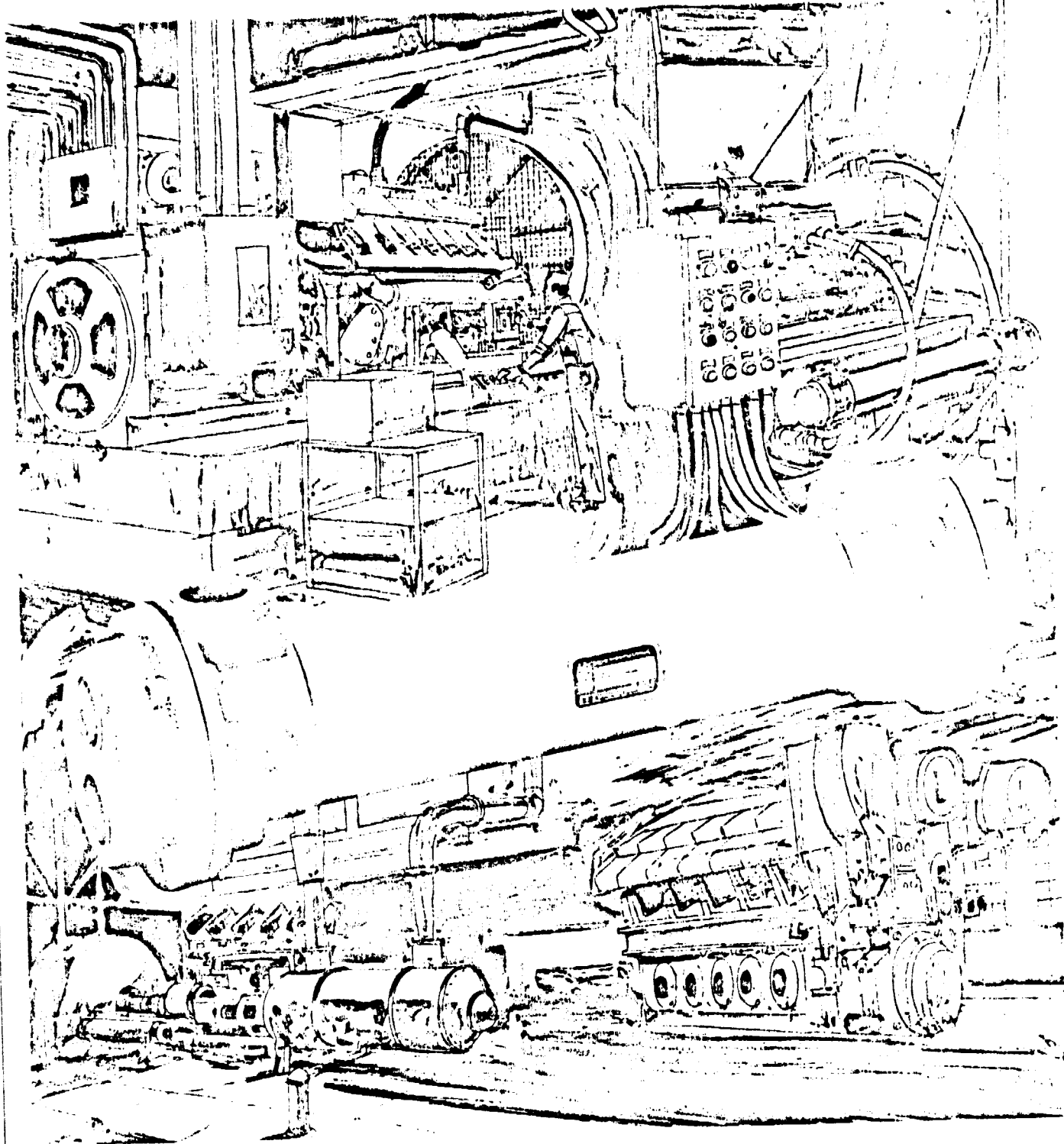
Special Seals:

250°F continuous (consult your local wholesaler, B&G representative or the factory)

## How to select a B&G Booster Pump

Required: 10 GPM at 6 ft. head. Look first at the bottom of the Booster Pump Capacity Chart where pump delivery is shown. Run a line straight up and from the 10 gallon point until it intersects a horizontal line from the 6 ft. head on scale at left. The nearest pump curve, or one slightly above this intersection is the proper selection. The Series 100 Booster pump should be used. It is not advisable to select a Booster pump with a head under 2 1/2 ft.

ORIGINAL PAGE 22 OF FOUR QUALITY



# Model STH Heat Exchangers

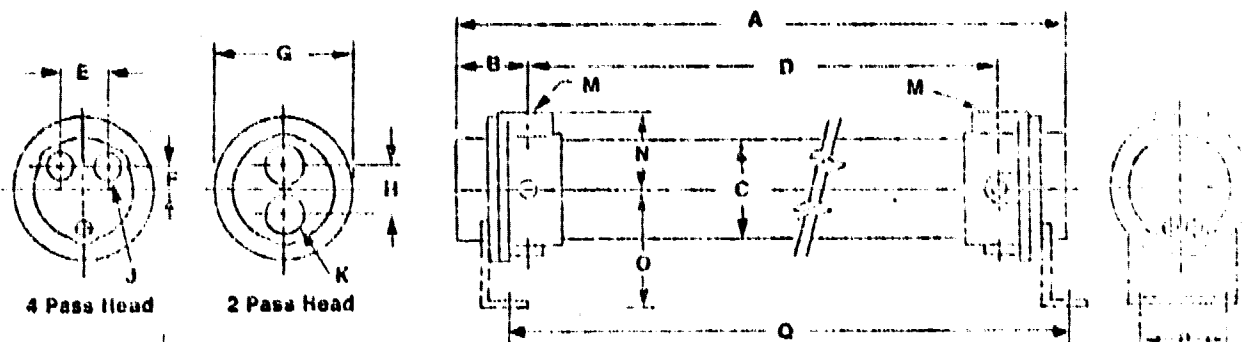
Fixed Tube Sheet Heat Exchanger

Liquid to Liquid  
Liquid to Gas  
Cooling and Heating

ORIGINAL PAGE 2  
OF POOR QUALITY

**BELL & GOSSETT**   
FLUID HANDLING DIVISION

# TYPE STH HEAT EXCHANGERS DIMENSIONS



All vent & drain  
tappings 1/4" NPT

	Tubeside	Shellside
Design Press.	150 PSI	225 PSI
Test Press.	200 PSI	300 PSI
Design Temp.	300°F	300°F

Material Specifications	
Heads-Cast Iron	Shell Copper
Tubesheets-Brass	Shell Ends-Brass
Tubes-STH300&400 Series 1/2 in. copper	
STH500&600 Series 3/4 in. copper	

MODEL	AREA sq. ft.	1 Pass		2 Pass		4 Pass		C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q**	Approx. Wt.
		A In.	B In.	A In.	B In.	A In.	B In.	In.	In.	In.	In.	In.	In.	In.	NPT	NPT	NPT	NPT	In.	In.	In.	in.	
STH-310*	4.2	17 1/2		17 1/2		17 1/2			13													15 1/4	16
STH-315*	5.9	23 1/2	2 1/2	23 1/2	2 1/2	23 1/2	2 1/2	3 1/2	19	1 1/2	3/4	4 1/2	1 1/2	3/4	3/4	1	1 1/2	1	2 1/2	2 1/2	3 1/2	21 3/4	19
STH-320*	7.6	29 1/2		29 1/2		29 1/2			25													27 3/4	22
STH-410*	7.2	17 1/2		17 1/2		17 1/2			12 1/2													15 1/4	22
STH-415*	10.0	23 1/2	2 1/2	23 1/2	2 1/2	23 1/2	2 1/2	3 1/2	18 1/2	1 1/2	1 1/2	5 1/2	1 1/2	3/4	1	1	2	1 1/2	3	3 1/2	3	21 3/4	32
STH-420*	12.9	29 1/2		29 1/2		29 1/2			24 1/2													27 3/4	46
STH-515*	13.0	24 1/2		24 1/2		23 1/2			19 1/2													21 1/2	50
STH-520*	16.7	30 1/2	3 1/2	30 1/2	3 1/2	29 1/2	2 1/2	5 1/2	24 1/2	2 1/2	1 1/2	6 1/2	2 1/2	3/4	1	1 1/2	2 1/2	1 1/2	3 1/2	4 1/2	3 1/2	27 1/2	56
STH-530*	24.0	42 1/2		42 1/2		41 1/2			36 1/2													39 1/2	68
STH-620*	28.2	31 1/2		30 1/2		30 1/2			24													27 1/2	74
STH-630*	40.8	43 1/2		42 1/2		42 1/2			36													39 1/2	93
STH-640*	53.4	55 1/2	3 1/2	54 1/2	3 1/2	54 1/2	3 1/2	6 1/2	48	2 1/2	1 1/2	7 1/2	3 1/2	3/4	1 1/2	2	3	2	4 1/2	4 1/2	3	51 1/2	112
STH-650*	66.0	67 1/2		66 1/2		66 1/2			60													63 1/2	131

\*No. of passes, either 1, 2 or 4.

\*\*Dimension for this arrangement only

Note: Dimensions subject to change without notice

OR FOR PART  
OF POOR QUALITY

## BELL & GOSSETT ITT SMALL TUBE HEAT EXCHANGERS

Bell & Gossett ITT Small Tube Heat Exchangers are ideally designed to satisfy the heat transfer requirements of any number of industrial applications—and are immediately available from factory stock. This means that there is no long wait for delivery once you give your Bell & Gossett representative the system requirements. Simply let him know what you need, and Bell & Gossett will computer-select the right unit for your particular requirements—right away.

You will probably find your area of interest covered in this sample list of industries and applications served by Bell & Gossett STH Model heat exchangers. But remember, for almost any heat exchanger applications you may have, your Bell & Gossett representative can come up with the right answer and products.

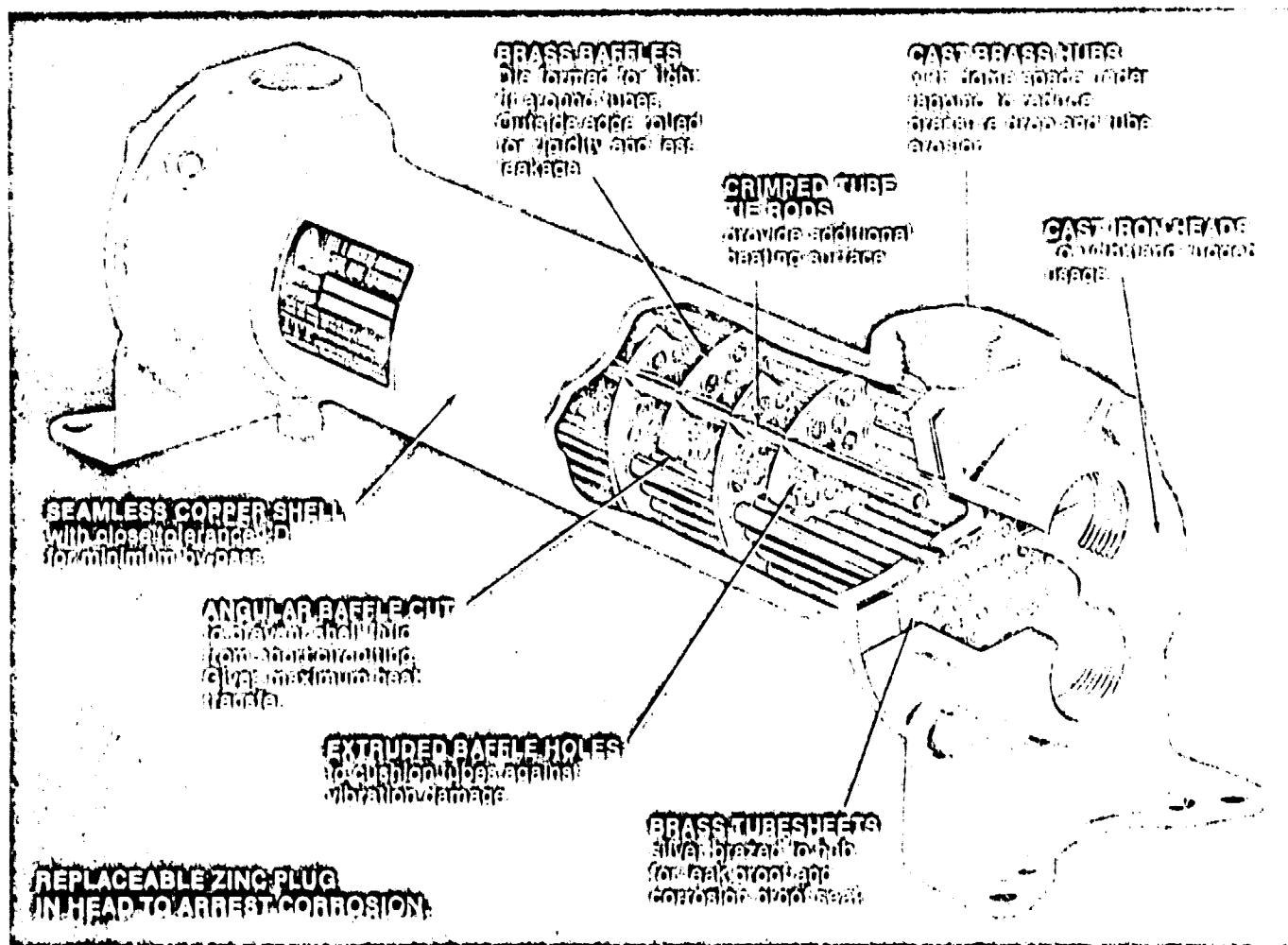
**Transformer Oil Cooling / Engine Oil Cooling / Injection Molding Machine Cooling / Mechanical Seal Cooling / Compressed Air Cooling / Cutting Fluid Cooling / Torque Converter Fluid Cooling / Solar Heat Transfer / Gas Turbines / Rectifiers / Laboratory Applications / Marine Applications / Machine Tools**

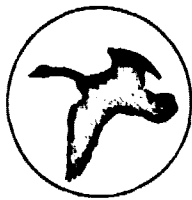
Bell & Gossett STH heat exchangers—in addition to being immediately available—incorporate advanced design techniques. Each unit has been computer-designed to be the best size for the job.

Angular baffle cut design prevents shell fluid short circuiting, insuring maximum heat transfer for your investment. The use of a crimped tube to serve as a tie rod also increases heat transfer surface.

Bell & Gossett designs are matched in quality by advanced manufacturing techniques. Unit components are precision die formed to insure an extremely tight fit.

Contact the Bell & Gossett representative in your area and let him use over fifty years of experience to solve your heat transfer problems.

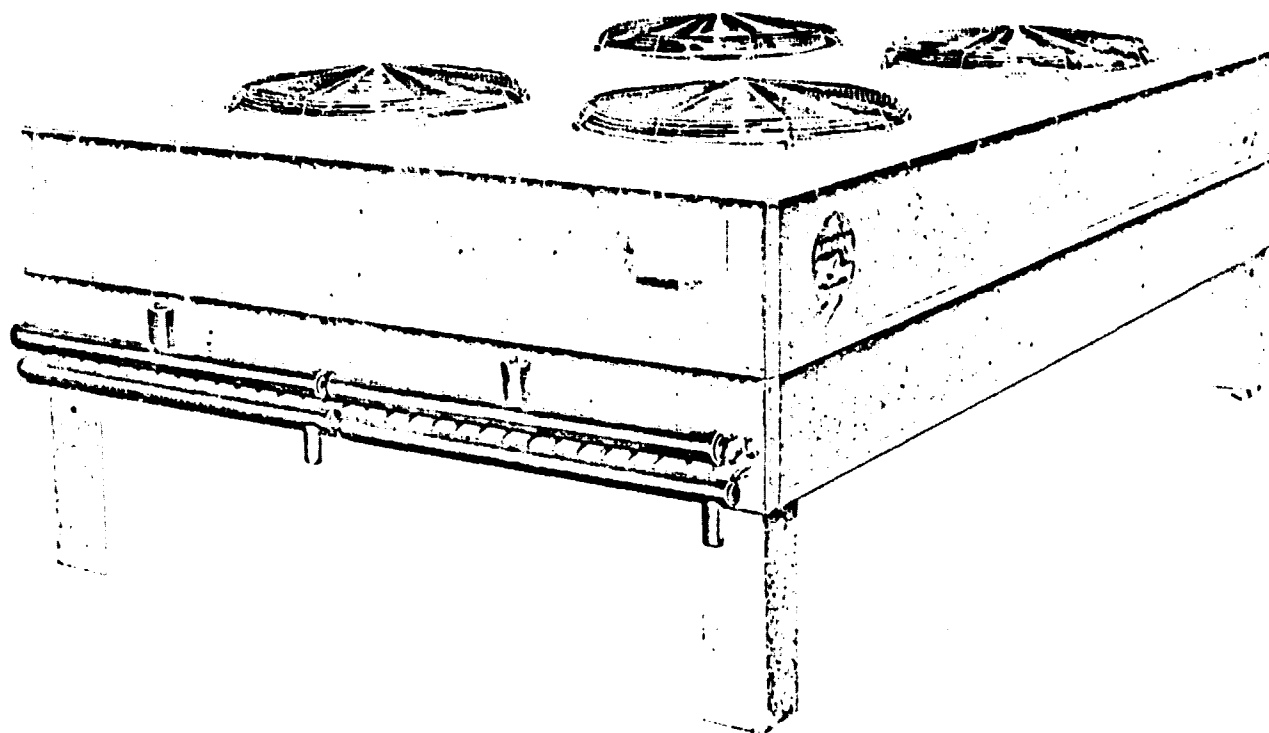




**McQUAY  
GROUP**

Catalog 630-7

## **Aircon<sup>®</sup>** air cooled refrigerant condensers

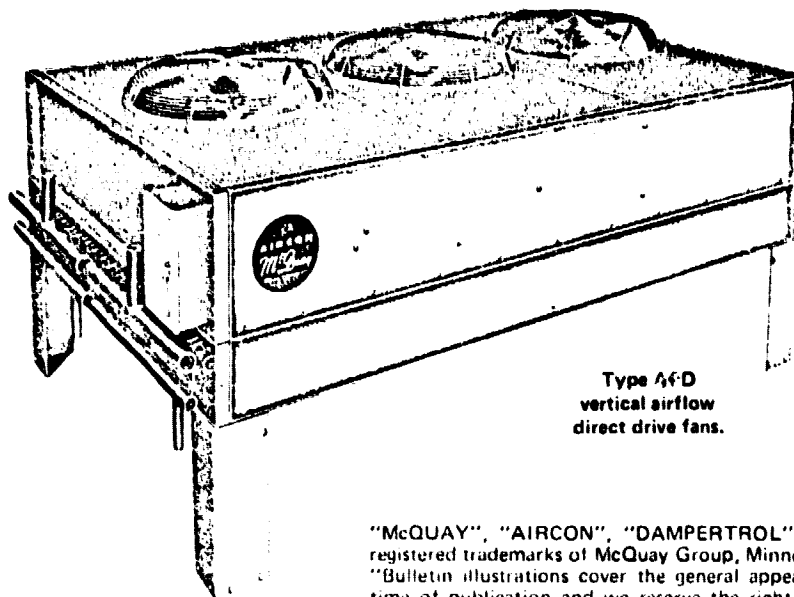


Listed by Underwriters'  
Laboratories, Inc.

**Type APD & APB; 7½-140 tons**

# McQUAY AIRCON<sup>®</sup>

## air cooled condensers



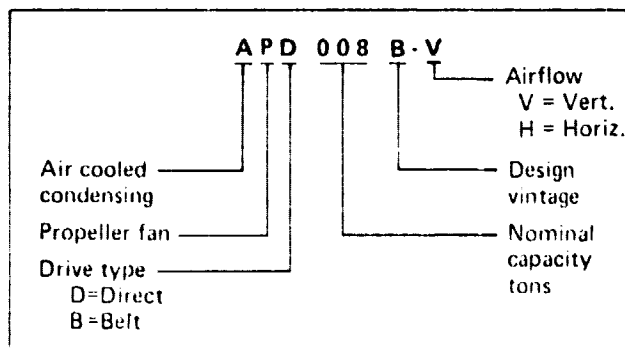
Type 46D  
vertical airflow  
direct drive fans.



Listed by  
Underwriters'  
Laboratories, Inc.

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### MODEL NOMENCLATURE



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Refrigerant charge calculation	14,15
Refrigerant piping data	15-17
Dimensional data	18
Physical data	19
Wiring diagrams	20-22
Engineering specifications	23

### BUILT TO PERFORM

The heart of any condenser is the heat exchanger surface, and the AIRCON air cooled condenser features the famous McQUAY HI-F coil with patented fin design. McQUAY has been designing and building coils since 1933, and the AIRCON HI-F condenser coil is the latest generation in a long, successful line. The coil is computer matched with high efficiency fans driven by inherently protected motors, providing you with the highest heat rejection capacity available.

### BUILT TO LAST

Heavy duty construction throughout insures long and satisfactory operation. Thick wall condenser coil tubes and fins, fans of aluminum or zinc plated iridite finish steel, weather protected condenser fan motors, with inherent protection, and heavy gauge galvanized steel cabinet all combine to give the service you expect.

### VERSATILITY OF APPLICATION

Designed to fill your condensing job requirements. Vertical or horizontal air flow, 23 sizes from 7 1/2 thru 140 nominal tons. The McQUAY AIRCON air cooled condenser offers complete flexibility in coil sectioning: single or dual section for water chiller or compressor unit remote condensing, or custom multi-section to serve the several compressors (with varying refrigerants and condensing temperatures) found in today's modern supermarkets. Optional factory or field installed packages for precise, all weather head pressure control, and sub-coolers to increase capacity and eliminate liquid line flash gas.

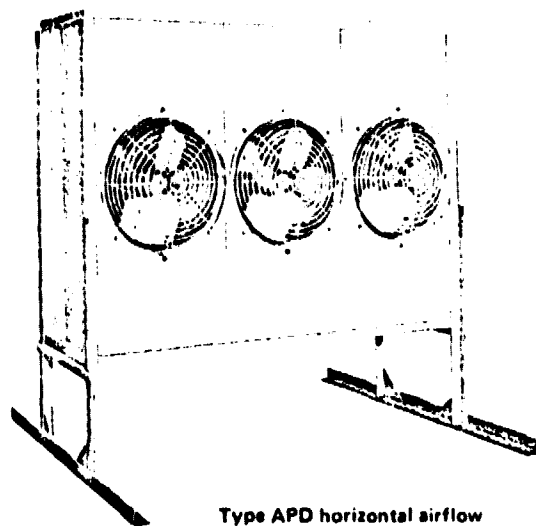
## The answer to your air cooled condenser needs...

Proven performance, high efficiency, reliability of operation and versatility of application make McQUAY your ideal choice. Over the years tens of thousands of AIRCON air cooled condensers have and still are proving themselves in the field. Designed by McQUAY engineers and manufactured to rigid quality standards for long life and superior operating efficiency, these units feature HI-F condenser coils, dynamically balanced fans driven by individual motors, rugged yet architecturally streamlined cabinet construction, plus numerous optional features to meet your special application.

OR LOCAL FAN  
OF POOR QUALITY

### ARCHITECTURALLY PLEASING

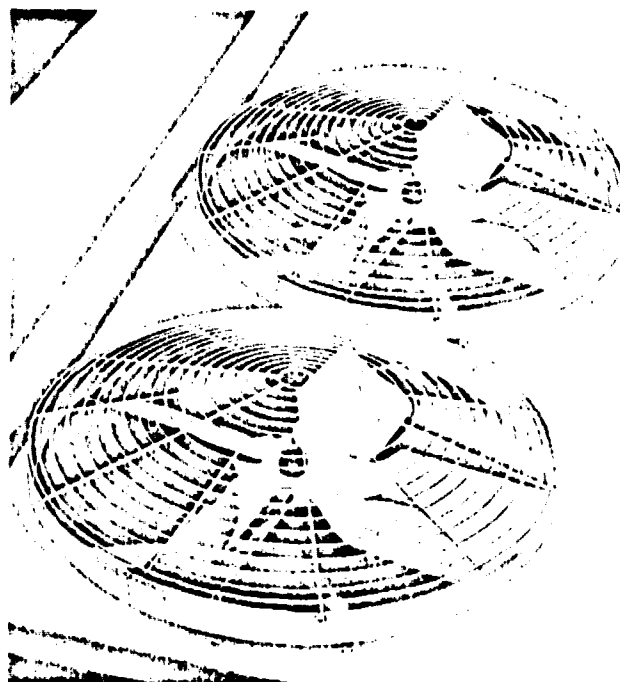
AIRCON air cooled condensers are designed to fit without marring your building silhouette. The complete line of APD direct drive vertical air flow units up to 100 tons are not more than 4 feet high including fan shrouds. APB belt drive units up to 140 tons are only 4 1/2 feet high.



Type APD horizontal airflow direct drive fans.

Multiple fans and inherently protected motors provide maximum protection against unit down time. Multiple fans with independent motors permit low cost FANTROL fan cycling head pressure control for operation in cooler weather. Direct drive fans (APD units) have aluminum blades riveted to a zinc plated steel hub. Belt drive fans (APB units) are zinc coated steel, iridite dipped, with heavy taperlock safety hubs. Fans operate at low tip speeds for minimum noise and vibration. All fans are statically and dynamically balanced and the unit is factory run before shipment. Full width partitions between fan sections prevent air bypass and eliminate fan windmilling in off-cycles due to nearby operating fans.

Inherent motor protection with automatic reset guards motors against locked rotor, single phasing and high ambient conditions. Direct drive motors are permanently lubricated ball bearing type with splashproof design and protected by a rain slinger. Single phase direct drive motors are PSC type for maximum economy. Belt drive motors are of the open drip proof design and are weather protected by the unit cabinet. Motors are factory wired to a convenient junction box, or to an optional FANTROL factory mounted panel.





# AIRCON® CONDENSER CAPACITIES

Table No. 4

TD	TOTAL HEAT REJECTION - BTUH R-12, SEE NOTES 2 AND 3 BELOW											
	TYPE APD DIRECT DRIVE UNIT SIZE											
	008B	010B	015B	020B	025B	030B	035B	040B	045B	050B	055B	060B
1	3,520	4,700	7,260	9,000	11,200	13,460	16,060	18,520	20,240	22,620	25,080	26,770
5	17,600	23,500	36,300	45,000	56,000	67,300	80,300	92,600	101,200	113,100	125,400	134,000
10	35,200	46,800	72,500	90,000	112,100	135,600	160,600	185,200	202,400	226,100	250,800	267,900
15	52,700	70,300	108,800	135,000	168,200	203,400	240,800	277,900	303,500	339,200	376,100	401,900
16	56,200	75,000	116,000	144,000	179,400	216,900	256,900	296,400	323,800	361,800	401,200	428,600
17	59,800	79,600	123,200	153,000	190,600	230,500	272,900	314,900	344,000	384,400	426,300	455,400
18	63,300	84,300	130,400	162,000	201,800	244,100	289,000	333,500	364,200	407,000	451,400	482,200
19	66,800	89,000	137,800	170,900	213,000	256,500	305,000	352,000	384,500	429,600	476,400	509,000
20	70,300	93,700	145,000	179,900	224,200	271,100	321,100	370,500	404,700	452,200	501,500	535,800
21	73,800	98,300	152,200	189,000	235,400	284,700	337,200	389,000	424,900	474,800	526,600	562,600
22	77,300	103,100	159,500	198,000	246,600	298,300	353,200	407,600	445,200	497,400	551,700	589,400
23	80,800	107,700	166,700	207,000	257,800	311,800	369,300	426,100	465,400	520,000	576,700	616,200
24	84,400	112,400	174,000	215,900	269,000	325,400	385,300	444,600	485,600	542,600	601,800	641,000
25	87,900	117,100	181,300	225,000	280,300	339,000	401,400	463,100	505,900	565,300	626,900	669,800
26	91,400	121,800	188,500	233,900	291,500	352,500	417,400	481,700	526,100	587,900	652,000	696,500
27	94,900	127,400	195,700	242,900	302,700	366,100	433,500	500,200	546,300	610,500	677,000	723,300
28	98,400	131,100	202,900	251,900	313,900	379,600	449,500	518,700	566,600	633,100	702,100	750,100
29	101,900	135,900	210,200	260,900	325,100	393,100	465,600	537,200	586,800	655,700	727,200	776,900
30	105,500	140,600	217,600	269,800	336,300	406,600	481,700	555,800	607,000	678,300	752,300	803,700
35	123,000	164,000	253,700	314,900	392,400	474,500	561,900	648,400	708,200	791,400	877,600	937,700
40	140,600	187,300	289,900	360,000	448,400	542,300	642,200	741,000	809,400	904,400	1,003,000	1,071,600

Table No. 4 (continued)

TD	TOTAL HEAT REJECTION - BTUH R-12, SEE NOTES 2 AND 3 BELOW											
	TYPE APD DIRECT DRIVE UNIT SIZE							TYPE APB BELT DRIVE UNIT SIZE				
	065B	070B	075B	080B	085B	090B	100B	110B	120B	130B	140B	
1	29,460	32,500	35,160	37,380	39,600	40,190	43,600	45,400	50,100	55,600	60,200	
5	147,300	162,500	175,800	186,900	198,000	201,000	218,000	227,000	250,500	278,000	303,700	
10	294,600	324,900	351,500	372,700	395,900	401,900	436,000	454,000	501,000	556,000	607,300	
15	441,900	487,400	527,300	560,500	593,800	602,900	654,000	681,000	751,500	834,000	911,000	
16	471,400	519,800	562,400	597,800	633,400	643,000	697,600	726,400	801,600	889,600	971,700	
17	500,800	552,300	597,600	635,200	673,000	683,200	741,200	771,800	851,700	945,200	1,032,500	
18	530,300	584,800	632,700	672,500	712,600	723,400	784,800	817,200	901,800	1,000,800	1,093,200	
19	559,700	617,300	667,900	707,900	752,100	763,600	828,400	862,600	951,900	1,056,400	1,153,900	
20	589,200	649,800	703,000	747,300	791,700	803,800	872,000	908,000	1,002,000	1,112,000	1,214,700	
21	618,700	682,300	738,200	794,600	831,300	844,000	915,600	953,400	1,052,100	1,167,600	1,275,400	
22	648,100	716,700	773,300	822,000	870,900	884,000	959,200	998,800	1,102,200	1,223,200	1,336,100	
23	677,600	747,300	808,500	859,300	910,500	924,400	1,022,800	1,044,200	1,152,300	1,278,800	1,396,800	
24	707,000	779,800	843,600	896,800	951,000	964,600	1,046,400	1,089,600	1,202,400	1,334,400	1,457,600	
25	736,500	812,300	878,800	934,100	989,700	1,004,800	1,090,000	1,135,000	1,252,500	1,390,000	1,518,300	
26	766,000	854,200	913,900	971,500	1,029,200	1,044,900	1,133,600	1,180,400	1,302,600	1,445,600	1,579,000	
27	795,400	877,200	949,100	1,008,900	1,068,800	1,085,100	1,177,200	1,225,800	1,352,700	1,501,200	1,639,800	
28	824,900	909,700	984,200	1,046,100	1,108,500	1,125,300	1,220,800	1,271,200	1,402,800	1,556,800	1,700,500	
29	854,300	942,200	1,019,400	1,083,600	1,148,000	1,165,500	1,264,400	1,316,600	1,452,900	1,612,400	1,761,200	
30	883,800	974,700	1,054,500	1,121,000	1,187,500	1,205,700	1,308,000	1,362,000	1,503,000	1,668,000	1,822,000	
35	1,031,100	1,137,200	1,230,300	1,307,200	1,385,600	1,406,700	1,526,000	1,589,000	1,753,500	1,946,000	2,125,600	
40	1,178,400	1,299,600	1,406,000	1,494,500	1,583,500	1,607,600	1,744,000	1,816,000	2,004,000	2,224,000	2,429,200	

- (1) TD - Condensing temperature minus ambient air temperature
- (2) For R-500, use R-12 rating; for copper fins, increase all ratings by 4%.
- (3) Ratings are at 60 Hertz. For 50 Hertz systems, multiply capacities by 0.90.

Multi-section AIRCON air cooled condensers are available for applications where more than one compressor is used either on the same system or separate systems. Usually, this arrangement will result in lower installation costs than installations using separate condensers.

Coils for multi-section units are factory circuited and divid-

ed into the proper number of sections, each sized to meet the specified capacity. Each section is supplied with a hot gas inlet and liquid outlet connection and tagged for identification. The last fan(s) on the multi-section unit should remain operative as long as a condensing requirement exists in any section of the unit.

## SAMPLE SELECTION

### GIVEN:

Six hermetic compressors with evaporator temperatures, design T.D.'s (or condensing temperatures) and capacities tabulated below.

Refrigerant R-12  
Ambient Temp. 100F

### PROCEDURE:

1. Tabulate customer data in columns 2, 3, 4 and also in column 5 when available. If heat rejection factors are not available (column 5), use factors from Table 3, Page 5. (Condensing Temp. = Ambient Temp. + T.D.)
2. Select T.D. adjustment factor from Table 8 and tabulate in column 6. This converts capacity to equivalent at 20 degrees T.D.
3. Multiply items in columns 4, 5 and 6 and list in column 7 for each section.
4. Add all items in column 7 to obtain the total BTUH required at 20 degree T.D. and use this value to select the proper AIRCON unit size.

### SELECTION:

Based on the total heat rejection capacity for the six compressors of 209,199 BTUH at 20 degree T.D., Table 7 shows that the smallest unit which will meet the requirements is an APD-025B with 224,200 BTUH. Table 7 also lists the heat rejection capacity per circuit of this unit as 9,342 BTUH (tabulated in column 8 below).

To determine the number of circuits required per section, divide column 7 by column 8 for each section. Example: Section No. 1 requires  $16,800 \div 9,342 = 1.79$  or 2 circuits.

The sample tabulation shows that 24 circuits are required when using an APD-025B and Table No. 7 indicates that 24 circuits are available for this model. If the total number of circuits required exceeds the number of circuits available, as listed in Table No. 7, it will be necessary to permit a slightly higher condensing temperature than planned for one or two of the sections. A second alternative would be to select the next larger unit size.

## SAMPLE TABULATION

1	2	3	4	5	6	7	8	9
SECTION NUMBER	DESIGN EVAPORATOR TEMP.	DESIGN TD	COMPRESSOR CAPACITY (BTUH)	HEAT REJECTION FACTOR	TD ADJUSTMENT FACTOR	ADJUSTED TOTAL BTUH REJECTED $4 \times 5 \times 6$	BTUH PER CIRCUIT @20° TD	NUMBER CIRCUITS REQUIRED
1	+20	25	15,000	1.40*	.80	16,800	9,342	2
2	-10	15	17,500	1.53*	1.33	35,611	9,342	4
3	+40	30	28,000	1.31	.67	24,576	9,342	3
4	-20	15	20,500	1.61*	1.33	43,897	9,342	5
5	-10	20	34,000	1.57	1.00	53,380	9,342	6
6	+20	20	25,500	1.37	1.00	34,935	9,342	4
						209,199		24

\* Interpolate from Table No. 3

## HEAT REJECTION CAPACITY

Table No. 7

MODEL NUMBER	Maximum No. of Circuits	20 DEGREES TD = COND TEMP-ENT AIR TEMP*					
		R-12		R-22		R-502	
		Total Unit Btuh	Btuh Per Circ.	Total Unit Btuh	Btuh Per Circ.	Total Unit Btuh	Btuh Per Circ.
APD-008B	12	70,300	5,858	74,000	6,170	72,520	6,043
APD-010B	12	93,700	7,808	98,600	8,220	96,628	8,052
APD-015B	24	145,000	6,041	152,600	6,360	149,548	6,231
APD-020B	24	179,900	7,495	189,400	7,890	185,612	7,733
APD-025B	24	224,200	9,342	236,000	9,830	231,280	9,636
APD-030B	24	271,100	11,295	285,400	11,890	279,692	11,653
APD-035B	24	321,100	13,379	338,000	14,080	331,240	13,801
APD-040B	24	370,500	15,437	390,000	16,250	382,200	15,925
APD-045B	24	404,700	16,862	426,000	17,750	417,480	17,395
APD-050B	34	452,200	13,300	476,000	14,000	466,480	13,720
APD-055B	34	501,500	14,750	527,500	15,515	517,400	15,218
APD-060B	34	535,800	15,759	564,200	16,594	552,800	16,259
APD-065B	34	589,200	17,329	619,200	18,212	607,600	17,871
APD-070B	68	649,800	9,555	684,000	10,050	670,320	9,857
APD-075B	68	703,000	10,338	740,000	10,880	725,200	10,664
APD-080B	68	747,300	10,989	786,600	11,560	770,868	11,336
APD-085B	68	791,700	11,642	833,400	12,250	816,732	12,010
APD-090B	68	803,800	11,821	845,800	12,438	829,000	12,191
APD-100B	68	872,000	12,824	917,500	13,493	900,000	13,235
APB-110B	68	908,000	13,353	956,700	14,069	936,000	13,705
APB-120B	68	1,002,000	14,735	1,053,300	15,490	1,033,000	15,191
APB-130B	68	1,112,000	16,353	1,170,800	17,218	1,146,000	16,853
APB-140B	68	1,214,700	17,863	1,278,400	18,800	1,252,000	18,412

\* Capacities at T.D.'s other than 20° can be found by dividing Table 7 capacities by Table 8 adjustment factors.

## TD ADJUSTMENT FACTOR

Table No. 8

DESIGN TD	ADJUSTMENT FACTOR
40	0.50
35	0.57
30	0.67
25	0.80
20	1.00
15	1.33
10	2.00

**Piping connections:** Hot gas and liquid connections for multi-section units should be sized according to the capacity of the condenser coil section served. Refer to page 17 for details.

Furnish and install as specified and as shown on plans . . . McQUAY Type (APB) (APD) air cooled condensers, arranged for (horizontal) (vertical) air flow. Condensers shall be multiple fan design and shall perform in accordance with (following schedule) (schedule on plans).

Each condenser shall consist of casing, condenser coil, multiple propeller fans driven by independent fan motors, fan guards and mounting legs. All fan motors shall be factory wired to a common electrical junction box. Units shall be U.L. listed.

**CONDENSER COIL**—The condenser coil shall be constructed of seamless copper tubes on a staggered tube pattern. Tubes shall be mechanically expanded into continuous, rippled (aluminum) (copper) plate type fins for permanent metal to metal contact. The fins shall have full depth fin collars completely covering the copper tube against atmospheric corrosion.

Copper tubes shall be attached to headers with heavy wall fittings for maximum resistance to piping strain and vibration due to discharge gas pulsation.

Coils shall have a working pressure of 425 PSIG. A 425 PSIG relief device, one per circuit, to be field installed.

Coils shall be factory leak tested, dehydrated, evacuated and sealed with caps brazed on coil connections.

**CASING**—The condenser casing shall be of heavy duty reinforced construction utilizing continuous galvanized steel. Casing shall be divided into individual fan sections by full width galvanized steel partitions.

Structural support members, including coil support frame, motor and drive support (APB Units) and legs shall be 7 and 10 gauge continuous galvanized steel for strength and corrosion resistance.

Large, latch-type access doors shall be provided adjacent to each motor on belt driven units for convenient access to interior of casing for maintenance and service of motor and drive.

**FAN AND FAN GUARD**—(APD-008B thru 100B) direct drive fans shall be aluminum with center hub of steel. The center hub shall be zinc plated for corrosion resistance.

(APB-110B thru 140B) belt drive fans shall be zinc plated steel with Iridite finish. Fan shall be secured to fan shaft by means of heavy taper-lock hub. Maximum fan diameter shall not exceed 48 inches. Fans shall be statically and dynamically balanced and factory run before shipment.

Fan guards shall be heavy gauge, close meshed, steel wire, zinc plated and Iridite dipped. Guard shall be contoured for maximum rigidity.

**DRIVE AND BEARINGS**—(APB-110B thru 140B) belt drive units shall have motor and bearings mounted on a common base of 10 gauge continuous galvanized steel. Bearings shall be heavy duty industrial type ball bearings and shall be provided with grease fittings. Permanently sealed bearings will not be accepted.

Steel fan shafts shall be ground and polished and coated with weather resistant dressing.

V-Belt Drives shall be designed on the basis of 24 hour per day operation with 2.0 drive service factor.

**MOTORS**—(APD-008B thru 100B) direct drive fan motors shall be weather protected, with built-in overload protection.

(APB-110B thru 140B) belt drive fan motors shall be positioned within unit casing for weather protection. Motors shall include built-in overload protection. Adjustable motor mount shall be provided for belt tension adjustment.

**HEAD PRESSURE CONTROL**—Condensing pressure controls shall be provided to maintain at least . . . F condensing temperature at . . . F minimum outdoor air temperature with compressor capacity reduction to . . . % and shall be automatic in operation without daily or seasonal adjustment. Control shall be as follows: *(Choose one.)*

Furnish FANTROL head pressure control to cycle condenser fans in response to ambient air temperature. Control package shall include condenser fan motor starting contactor(s) and line voltage thermostat(s) in a weather tight enclosure.

Furnish SPEEDTROL head pressure control consisting of fan cycling in response to ambient temperatures and speed modulation of last fan(s) on, in direct response to refrigerant head pressure.

Furnish DAMPERTROL head pressure control consisting of fan cycling in response to ambient temperatures and face and bypass damper modulation of last fan(s) on, in direct response to refrigerant head pressure.

Furnish SEASONTROL head pressure control consisting of three way modulating valves to control head pressure by back flooding the condenser coil with liquid refrigerant. System shall provide adequate hot gas pressure to liquid line during cold start.

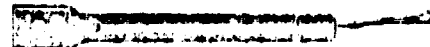
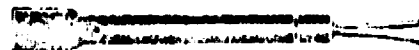
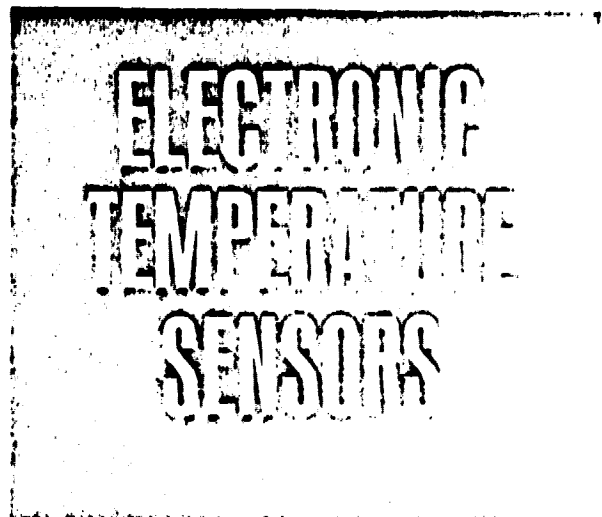
# Honeywell

THE C773 IS A PLATINUM FILM SENSOR WHICH HAS A POSITIVE TEMPERATURE COEFFICIENT. ON A RISE IN AMBIENT TEMPERATURE THE RESISTANCE OF THE SENSOR INCREASES.

- ☐ C773A contains a single sensor for storage tank or solar collector mounting.
- ☐ C773B contains a double sensor for storage tank or solar collector applications.
- ☐ C773C contains a single sensor with a flattened end and mounting hole for easy solar collector installation.
- ☐ C773D contains a double sensor with a flattened end and mounting hole for easy solar collector installation.
- ☐ Available with a medium or high ambient temperature range (specify when ordering).
- ☐ Immersion well and remote sensor wiring compartment available separately.

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C773A

Part Number

10 77 (.03)

# SPECIFICATIONS

## IMPORTANT

THE SPECIFICATIONS GIVEN IN THIS PUBLICATION DO NOT INCLUDE NORMAL MANUFACTURING TOLERANCES. THEREFORE, THIS UNIT MAY NOT MATCH THE LISTED SPECIFICATIONS EXACTLY. ALSO, THIS PRODUCT IS TESTED AND CALIBRATED UNDER CLOSELY CONTROLLED CONDITIONS, AND SOME MINOR DIFFERENCES IN PERFORMANCE CAN BE EXPECTED IF THOSE CONDITIONS ARE CHANGED.

### TRADELINE MODELS AVAILABLE:

**C773A Temperature Sensor.** Single sensor mounts in storage tank using immersion well or on collector with mounting clip.

**C773B Temperature Sensor.** Double sensor mounts in storage tank using immersion well or on collector with mounting clip.

**C773C Temperature Sensor.** Single sensor has flattened end with mounting hole for collector installation.

**C773D Temperature Sensor.** Double sensor has flattened end with mounting hole for collector installation.

### LEADWIRE:

**C773A,C**-two black 18 inch [457.2 mm], No. 22, NEC Class 1.

**C773B,D**-two black, two white, 18 inch [457.2 mm], No. 22 stranded, NEC Class 1.

**TEMPERATURE RANGE:** Minus 50 to plus 450 F [minus 46 to plus 232 C].

**DIMENSIONS:** See Figs. 2 and 3.

### ACCESSORIES:

**Immersion Well**-for mounting sensor in storage tank. See Table 1 and Fig. 1.

**Remote Sensor Wiring Compartment**-for wiring storage tank sensor, Part No. 111892F.

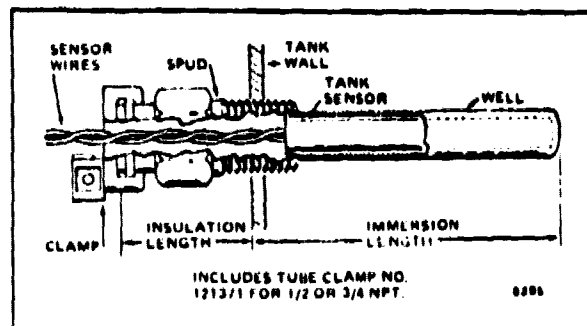


FIG. 1-TANK SENSOR INSERTED IN IMMERSION WELL.

TABLE 1 - IMMERSION WELL TABLE

IMMERSION LENGTH		INSULATION LENGTH		SELECT WELL MATERIAL AND ORDER NUMBER BELOW			
				COPPER		STAINLESS STEEL	
in.	mm	in.	mm	1/2 NPT	3/4 NPT	1/2 NPT	3/4 NPT
3 3/8	85.7	1-1/2	38.1	121731A	121371B	121371E	121371F
3 3/8	85.7	1-1/2	38.1	—	121371K <sup>a</sup>	—	—
3 3/8	85.7	3	76.2	121371L	121371M	—	—
3 3/8	85.7	4	101.6	122554A <sup>a</sup>	122555A <sup>a</sup>	—	—
5 3/8	136.5	4	101.6	122554B <sup>a</sup>	122555B <sup>a</sup>	—	—
6	152.4	1-1/4	31.8	112620BB	—	—	—

<sup>a</sup>Has plastic sleeve on insertion well.

continued on page 3

## ORDERING INFORMATION

WHEN PURCHASING REPLACEMENT AND MODERNIZATION PRODUCTS FROM YOUR TRADELINE WHOLESALE OR YOUR DISTRIBUTOR, REFER TO THE TRADELINE CATALOG OR PRICE SHEETS FOR COMPLETE ORDERING NUMBER, OR SPECIFY—

1. Order number.
2. Accessories (immersion well remote sensor wiring compartment).

IF YOU HAVE ADDITIONAL QUESTIONS, NEED FURTHER INFORMATION, OR WOULD LIKE TO COMMENT ON OUR PRODUCTS OR SERVICES, PLEASE WRITE OR PHONE:

1. YOUR LOCAL HONEYWELL RESIDENTIAL DIVISION SALES OFFICE (CHECK WHITE PAGES OF PHONE DIRECTORY).
2. RESIDENTIAL DIVISION CUSTOMER SERVICE  
HONEYWELL INC., 1885 DOUGLAS DRIVE NORTH  
MINNEAPOLIS, MINNESOTA 55422 (612) 542-7500

(IN CANADA—HONEYWELL CONTROLS LIMITED, 740 ELLESMERE ROAD, SCARBOROUGH, ONTARIO M1P 2V9)  
INTERNATIONAL SALES AND SERVICE OFFICES IN ALL PRINCIPAL CITIES OF THE WORLD.

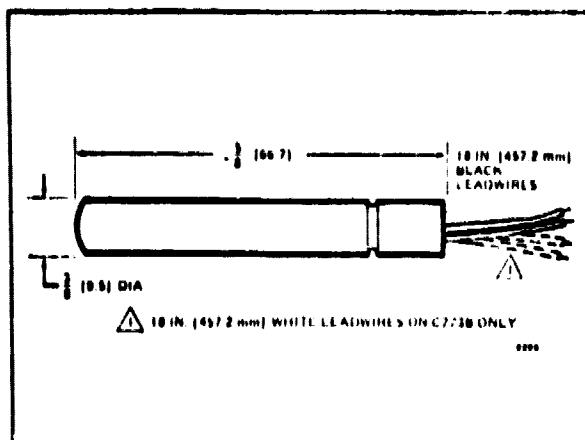


FIG. 2-C773A,B DIMENSIONS IN INCHES (MILIMETRES IN BRACKETS).

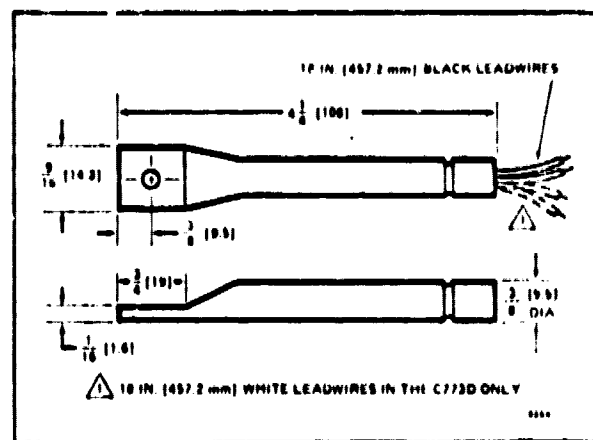


FIG. 3-C773C,D DIMENSIONS IN INCHES (MILIMETRES IN BRACKETS).

## INSTALLATION

### CAUTION

1. Installer must be trained and experienced.
2. Disconnect power supply before connecting wiring to prevent electrical shock or equipment damage.
3. Always conduct a thorough checkout as outlined in the instructions with the primary control when installation is complete.

### LOCATION

Follow the system manufacturer's recommendations for the best location of the sensor. Each sensor should be located so that it experiences the most useful temperature for proper system operation.

### MOUNTING SENSOR

Mount C773A,B as a storage tank sensor using an immersion well as follows:

1. Drain system fluid to a point below the sensor fitting.
2. Screw the well into the threaded fitting. Use an approved pipe dope or Teflon tape to seal the threads.
3. Refill system and check for leaks.
4. Insert the sensor probe into the immersion well until it bottoms. See Fig. 1.
5. Attach retainer clamp over groove on well spud. Fit wires in clamp groove and lightly tighten screw. Do not overtighten.

Install C773A,B as a collector sensor using the mounting clip provided and No. 8 screw. Mount C773C,D as a collector sensor using the flattened end with mounting hole and a No. 8 or 10 screw.

Temperatures in excess of 450 F [232 C] will damage the sensor. Shield the sensor against possible overtemperature conditions prior to system operation. Do not mount collector sensor to collector fluid channels.

### WIRING

### WARNING

1. Shield the sensor against possible overtemperature condition, prior to system operation.
2. On unglazed collectors mount the sensor with leadwires down to keep sensor from accumulating water.
3. Wire additions to the leadwires must be capable of withstanding a temperature of 450 F [232 C].

All wiring must comply with applicable codes and ordinances. The C773 can be used for numerous applications in solar energy systems. Fig. 4 shows the sensors wired to an R7412 Differential Temperature Controller.

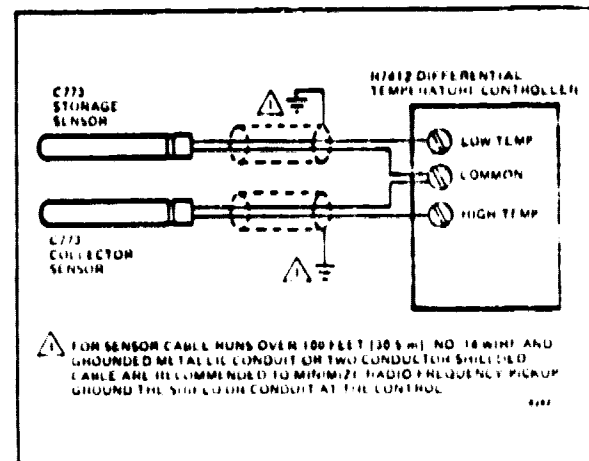


FIG. 4-WIRING C773 TO R7412 DIFFERENTIAL TEMPERATURE CONTROLLER.

For the C773B and C773D Temperature Sensors, the two black leadwires belong to one sensor and the two white leadwires belong to the other sensor.

If the amount of sensor cable used exceeds 100 feet [30.5 m], use No. 14 wire and grounded metallic conduit or two conductor shielded cable. Connect the shield or conduit to ground at the controller. Grounded metallic

conduit or shielded cable (such as Belden 8762 or equivalent) minimizes possible radio frequency signal interference.

Remote Sensor Wiring Compartment (Part No. 111892F) is available for tank sensor wiring (see Accessories).

## OPERATION AND CHECKOUT

### OPERATION

The C773 is a platinum film sensor packaged in a copper capsule. The sensor has a positive temperature coefficient; on a rise in ambient temperature the resistance of the sensor increases (Fig. 5).

### CHECKOUT

Make certain that each sensor is securely mounted. When observing the system in operation, check that the sensors are correctly located. Each sensor should be located so that it experiences the most useful temperature for proper system operation.

To determine the temperature which the sensor is experiencing, use a high resistance ohmmeter (20,000 ohm/volt or greater) to measure the resistance of the sensor. This measurement may be converted to a temperature reading using Fig. 5. Check a variety of temperature locations to insure that the sensor reading is providing the most accurate temperature for proper system operation.

If the sensors are not providing correct temperature readings because of location, change the location and mount properly.

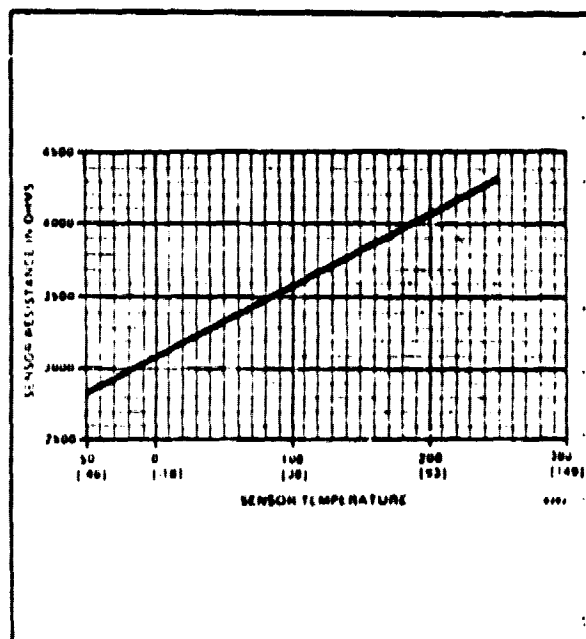


FIG. 5—CONVERTING SENSOR RESISTANCE INTO DEGREES F (C).

# Honeywell

THE L4029E AND F MANUAL RESET LIMIT CONTROLS OPEN A LINE OR LOW VOLTAGE CIRCUIT IF THE AIR TEMPERATURE REACHES A CRITICAL LEVEL AT THE LIMIT CONTROL LOCATION. THE LIMIT CONTROL MAY BE USED AS A FIRE STAT IN THE DUCTWORK OF AIR CONDITIONING AND VENTILATING SYSTEMS. IF THE CIRCULATED AIR REACHES A TEMPERATURE INDICATIVE OF FIRE, THE LIMIT CONTROL SHUTS OFF THE FAN. THE L4029 LIMIT CONTROL WILL PREVENT THE FAN FROM CONTRIBUTING TO THE SPREAD OF A FIRE.

□ The L4029E and F are also suitable for use with any warm air furnace to provide positive lockout of the burner in the event of fan failure.

□ Internal snap switch actuated by a bimetal strip inserted directly into the air stream responds rapidly to temperature changes.

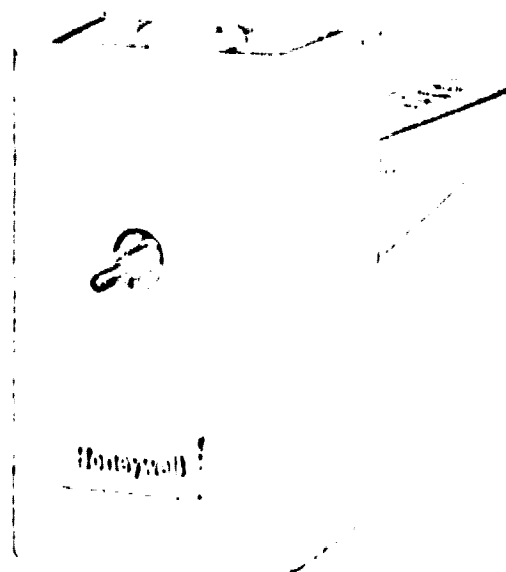
□ Switch breaks and locks out to stop burner or fan operation when the temperature rises to the cutout point.

□ When temperature falls approximately 25 degrees below the cutout point, the switch may be reset by pushing the button and releasing.

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LIMIT CONTROL



L4029E

Resistor Co. Co. Co. Co.

10-75



# SPECIFICATIONS

## TRADELINE MODELS

**MODEL:** L4029E TradeLine Manual Reset Limit Control with case and cover.

**CUTOUT SETTING (fixed):** To break the circuit at 125 or 165 F.

**ELECTRICAL RATINGS (in amperes):**

	30V AC	120V AC	240V AC
Full Load	2	10	5
Locked Rotor	—	60	30

0.25 amp full load at 0.25 to 12V dc.

2000 VA maximum connected load.

**SWITCH ACTION:** Opens circuit and locks out on temperature rise to cutout point.

**MAXIMUM AMBIENT TEMPERATURE:** At switch 190 F, at bimetal 350 F.

**MANUAL RESET:** Button through front of cover. Must be pressed and released to remake switch after temperature falls approximately 25 degrees below the cutout point.

**DIFFERENTIAL:** Manual reset only, after approximately 25 F drop in temperature.

**DIMENSIONS (in inches; excluding element):**

L4029E—3-3/4 high, 2-5/16 wide, 2 deep (see Fig. 1).

**ELEMENT INSERTION LENGTH (in inches):** 3-1/8.

**MOUNTING MEANS:**

L4029E—two screw holes are provided through back of case (see Fig. 1).

**WIRING KNOCKOUTS (L4029E):** Bottom—for 1/2 inch conduit.

**FINISH:** Smooth gray.

## STANDARD MODELS

**MODEL:**

L4029E Manual Reset Limit Control with case and cover.

L4029F Manual Reset Limit Control less case and cover.

**CUTOUT SETTING (fixed):** To break the circuit at 125, 135, 165, 200, or 240 F.

**ELECTRICAL RATINGS (in amperes):**

	30V AC	120V AC	240V AC
Full Load	2	10	5
Locked Rotor	—	60	30

0.25 amp full load at 0.25 to 12V dc.

**SWITCH ACTION:** Normally closed spst switch opens on temperature rise to the set point. Switch must be manually reset to operate.

**MAXIMUM AMBIENT TEMPERATURE:** At switch 190 F, at bimetal 350 F.

**MANUAL RESET:** Button through front cover. Must be pressed and released to remake switch after temperature falls approximately 25 degrees below the cutout point.

**DIFFERENTIAL:** Manual reset only, after approximately 25 F drop in temperature.

**DIMENSIONS (in inches; excluding element):**

L4029E—3-3/4 high, 2-5/16 wide, 2 deep (see Fig. 1).

L4029F—2-3/4 high, 1-7/8 wide, 1-15/32 deep (see Fig. 2).

**ELEMENT INSERTION LENGTH (in inches):** 3 or 7 inches.

**MOUNTING MEANS:**

L4029E—two screw holes are provided through back of case (see Fig. 1).

L4029F—two screw notches are provided through the backplate (see Fig. 2).

**WIRING KNOCKOUTS (L4029E):** Bottom—for 1/2-inch conduit.

**FINISH:** Smooth gray.

**UNDERWRITERS' LABORATORIES, INC. LISTED:** L4029E, File No. MP465 Guide No. 167E7.

**UNDERWRITERS' LABORATORIES, INC. COMPONENT RECOGNIZED:** L4029F, File No. MP466, Guide No. 167E7.

(continued on page 3)

## ORDERING INFORMATION

WHEN PURCHASING REPLACEMENT AND MODERNIZATION PRODUCTS FROM YOUR TRADELINE WHOLESALE OR YOUR DISTRIBUTOR, REFER TO THE TRADELINE CATALOG OR PRICE SHEETS FOR COMPLETE ORDERING NUMBER.

**SPECIFY—**

1. MODEL NUMBER.
2. ELEMENT LENGTH DESIRED (3 OR 7 INCHES).
3. CUTOUT POINT DESIRED.

IF YOU HAVE ADDITIONAL QUESTIONS, NEED FURTHER INFORMATION, OR WOULD LIKE TO COMMENT ON OUR PRODUCTS OR SERVICES, PLEASE WRITE OR PHONE:

1. YOUR LOCAL HONEYWELL RESIDENTIAL DIVISION SALES OFFICE (CHECK WHITE PAGES OF PHONE DIRECTORY).
2. RESIDENTIAL DIVISION CUSTOMER SERVICE  
HONEYWELL INC., 1805 DOUGLAS DRIVE NORTH  
MINNEAPOLIS, MINNESOTA 55422 (612) 542-7500

(IN CANADA—HONEYWELL CONTROLS LIMITED, 740 ELLESMERE ROAD, SCARBOROUGH, ONTARIO M1P 2V9)  
INTERNATIONAL SALES AND SERVICE OFFICES IN ALL PRINCIPAL CITIES OF THE WORLD.

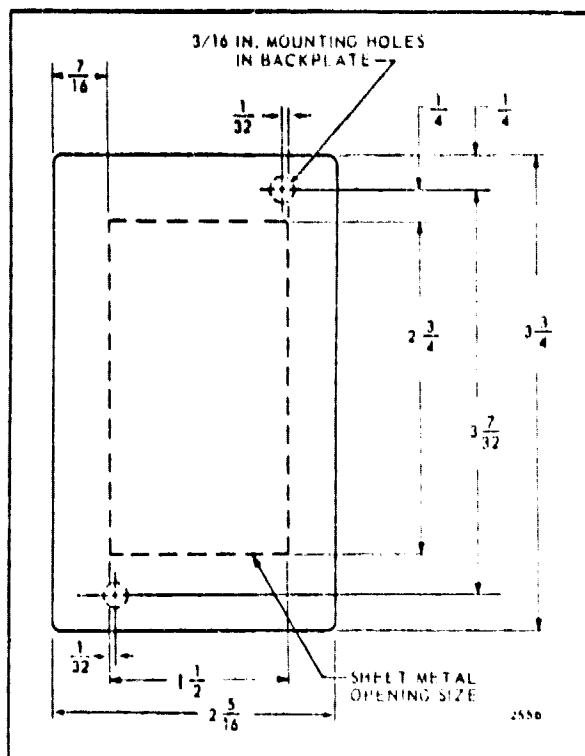


FIG. 1—MOUNTING AND CASE DIMENSIONS IN INCHES FOR L4029E.

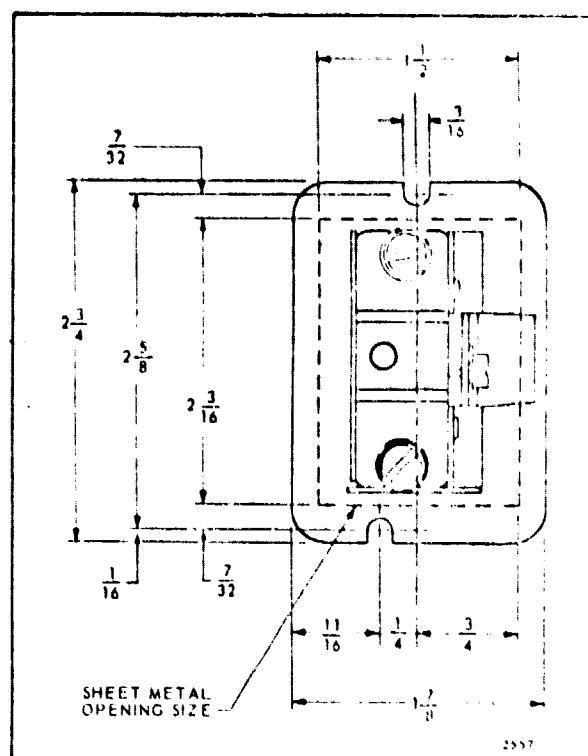


FIG. 2—MOUNTING AND BACKPLATE DIMENSIONS IN INCHES FOR L4029F.

## INSTALLATION

1. Installer must be a trained, experienced serviceman.
2. Disconnect power supply before making wiring connections to prevent electrical shock and equipment damage.
3. Always conduct a thorough checkout when installation is complete.

### LOCATION

L4029E or F should be mounted where the element can respond quickly to air temperature changes in the system. In a ventilating or air conditioning installation, the safety control is normally installed with element just upstream of fan. Where there is no intake duct, the L4029E or F may be mounted on a suitable bracket so the air entering the fan is drawn across the element. In a downflow furnace installation, locate the L4029E or F between filter(s) and blower where the circulation of air is not restricted by baffles. Do not permit element guard to touch filter or other internal parts.

### MOUNTING

At selected location, cut a hole in sheet metal to clear element guard, and drill holes for mounting

screws (see Fig. 1). Remove cover (L4029E), insert element into hole, and fasten control securely with screws.

### WIRING

All wiring must agree with local codes and ordinances.

In all installations follow the equipment manufacturer's instructions. If not available, the typical circuits in Figs. 3-5 can be used.

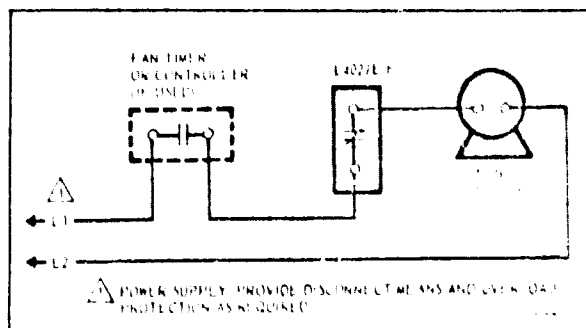


FIG. 3—TYPICAL DIAGRAM OF L4029E OR F IN VENTILATING FAN CIRCUIT.

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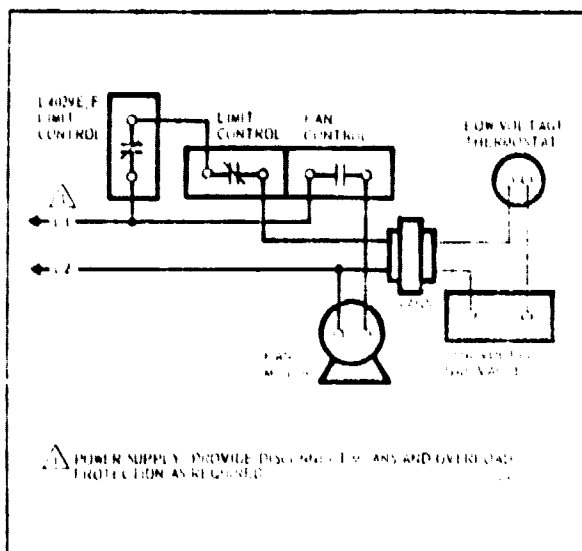


FIG. 4—TYPICAL DIAGRAM OF L4029E OR F IN GAS-FIRED DOWNFLOW FURNACE CIRCUIT.

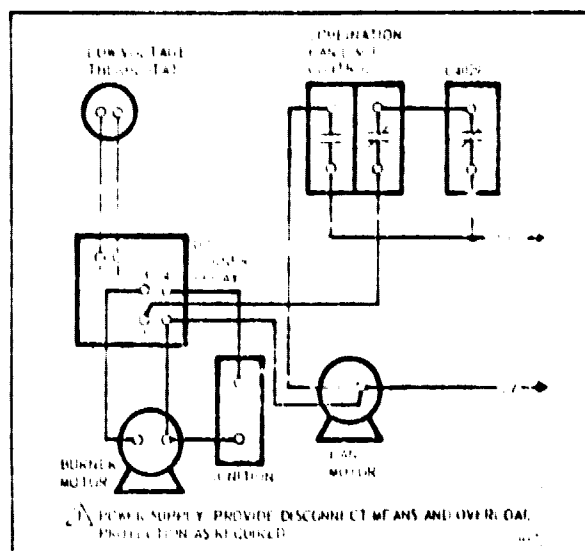


FIG. 5—TYPICAL DIAGRAM OF L4029E OR F IN OIL-FIRED DOWNFLOW FURNACE CIRCUIT.

## CHECKOUT

There are no field adjustments to make on the L4029E or F.

### TO RESET

When the temperature has dropped approximately 25 degrees (F) below cutout point, push and release the button protruding through the cover.

1. If the limit control should require servicing or replacement, be sure to order by model number.
2. Never use a lighted match to heat the bimetal element for checking the operation.

3. Limit controls do not require lubrication.

Before leaving the job, check the installation as follows:

1. Disconnect the fan from its power supply.
2. Turn on the burner by operating the thermostat.
3. The L4029 will shut off the burner when the plenum temperature reaches the limit setting of the control.
4. If the L4029 fails to shut the burner off, check the installation and wiring carefully. Retest. If control still fails to shut off burner, replace control.

# Honeywell

THE M445 AND M845 ARE 2 POSITION, SPRING RETURN MODUTROL MOTORS. THEY ARE USED TO OPERATE DAMPERS OR VALVES IN APPLICATIONS WHERE IT IS NECESSARY OR DESIRABLE TO HAVE THE CONTROLLED ELEMENT RETURN TO THE STARTING POSITION IN THE EVENT OF POWER FAILURE OR INTERRUPTION.

☐ The M445 operates on line voltage; the M845 operates on 24V ac.

☐ The M445C and M845B are equipped with internal, thermostatically controlled heaters for use in cold weather applications.

☐ The M445B and M845E are designed for normally open valves; all other motors are normally closed.

☐ All models have a one minute, 160 degree stroke.

☐ Sturdy, lightweight, die cast aluminum case.

☐ Integral spring returns motor to normal position when power fails or is interrupted.

☐ Built-in spdt adjustable switch is available on some models for the control of auxiliary equipment.

☐ Oil immersed gear train assures long life and quiet operation.

☐ Full line of accessories includes weather-proofing kit and explosion-proof housing as well as auxiliary switches and a number of linkages.

☐ Tradeline M445A includes multitap transformer for 120, 208/240V ac control circuits.

S.K.  
REV. 7-75 (025)

MODUTROL  
MOTORS

ORIGINAL FACTORY  
OF BEST QUALITY

M445 1.2.2.2  
M845 1.2.2.2

Reprints of this Brochure

10-200V

# SPECIFICATIONS

## TRADELINE MODELS

Tradeline models of this device are selected and packaged to provide ease of stocking, ease of handling, and maximum replacement value. Tradeline model specifications are the same as those of standard models except as noted below:

### TRADELINE MODELS AVAILABLE: M845A

Modutrol Motor—2 position, spring return motor for use with dampers and normally closed valves.

An internal spdt switch is provided for actuating auxiliary equipment. Motor operates from 24V ac and includes a cover mounted transformer for 120/208/240V ac control circuits.

**ELECTRICAL RATINGS:** Voltage and frequency—motor requires 24V ac, 60 Hz. Cover mounted

transformer has 120/208/240V ac multitap primary and 24V ac secondary.

### ADDITIONAL FEATURES:

- Multitap transformer for 120/208/240V ac control circuits.
- Tradeline pack with cross reference label and special instruction sheet.

## STANDARD MODELS

### MODELS:

The M445 and M845 are 2 position, spring return Modutrol motors with 1 internal auxiliary spdt switch. They are for use with dampers and normally closed valves (except M445B and M845E are for normally open valves).

M445A—Modutrol motor as described above for line voltage operation.

M445B—Modutrol motor as described above for line voltage operation with normally open valves.

M445C—Modutrol motor as described above for line voltage operation. Includes internal thermostatically controlled heater.

M445D—Modutrol motor as described above for line voltage operation; without auxiliary switch.

M845A—Modutrol motor as described above for 24 volt operation. Available with 120/208/240V ac multitap cover mounted transformer (see Tradeline specifications).

M845B—Modutrol motor as described above for 24 volt operation. Includes internal thermostatically controlled heater. Available with 120V ac cover mounted transformer.

M845C—Modutrol motor as described above for 24 volt operation; without auxiliary switch.

M845E—Modutrol motor as described above for 24 volt operation with normally open valves. With 120V ac cover mounted transformer.

### ELECTRICAL RATINGS:

MODEL	WATTS	VA	VOLTAGE, AC 50/60 HZ
M445A	17	21	120, 208, 220 <sup>a</sup> , 240
M445B	17	21	120
M445C	47 <sup>b</sup>	53	120
M445D	17	21	120
M845Ac	18	21	24
M845Bc	49 <sup>b</sup>	51	
M845C	18	21	
M845Ed	18	21	

<sup>a</sup>50 Hz only.

<sup>b</sup>Including 30 watts for internal heater.

<sup>c</sup>Available with cover mounted transformer.

<sup>d</sup>Includes cover mounted transformer.

### AUXILIARY SWITCH RATING<sup>a</sup> (in amperes):

	120V AC	240V AC
Full Load	7.2	3.6
Locked Rotor	43.2	21.6

<sup>a</sup>Switch rating is for one contact only; if both are used, second contact is rated 40 VA.

(continued on page 3)

# ORDERING INFORMATION

WHEN ORDERING REFER TO THE TRADELINE CATALOG OR PRICE SHEETS FOR COMPLETE ORDERING SPECIFICATION NUMBER, OR ...

### SPECIFY—

1. MODEL NUMBER, SPECIFY TRADELINE IF DESIRED.
2. VOLTAGE AND FREQUENCY, ON MODELS WITH COVER MOUNTED TRANSFORMER AVAILABLE, SPECIFY WHEN ORDERING.
3. ACCESSORIES, IF REQUIRED.

### ORDER FROM—

1. YOUR USUAL SOURCE, OR
2. HONEYWELL  
1885 DOUGLAS DRIVE NORTH  
MINNEAPOLIS, MINNESOTA 55422  
(IN CANADA—HONEYWELL CONTROLS LIMITED  
740 ELLESMERE ROAD  
SCARBOROUGH, ONTARIO)  
INTERNATIONAL SALES AND SERVICE OFFICES  
IN ALL PRINCIPAL CITIES OF THE WORLD.

**INTERNAL HEATER THERMOSTAT (M445C, M845B ONLY):** Automatically makes at 20 F on temperature fall, breaks at 50 F on temperature rise.

**CRANK SHAFT:** Double ended shaft, 3/8 inch square.

**STROKE:** 160 degrees.

**DUTY CYCLE:** Unlimited.

**MAXIMUM OPERATING TORQUE:** 50 pound-inches (may be divided between the 2 ends of motor if no more than 25 pound-inches is applied to auxiliary end).

**DEAD WEIGHT LOAD ON SHAFT:**

Power end—200 pounds.

Auxiliary end—10 pounds.

**AMBIENT TEMPERATURE RATING:**

Maximum—125 F.

Minimum—15 F (minus 40 F with internal heater).

**UNDERWRITERS' LABORATORIES, INC.**

**LISTED:** M445A,B,D and M845A,B,E—File No. E4436, Guide No. XAPX. (NOTE: Only motors with line voltage or auxiliary switches require listing.)

**DIMENSIONS:** See Fig. 1.

**ACCESSORIES:**

**Q607 Auxiliary Switch—**controls auxiliary equipment as a function of motor position.

**Q605 Damper Linkage—**connects motor to damper. **INCLUDES MOTOR CRANK ARM.**

**Cover-transformer—**die-cast aluminum cover with built-in transformer. Part No. 130810A has 120V ac primary and 24V ac secondary; Part No. 130810B has multitap primary for 120/208/240V ac and 24V ac secondary.

**Q601 Linkage—**connects Modutrol motor to water or steam valve.

**Q100 Linkage—**connects Modutrol motor to butterfly valve.

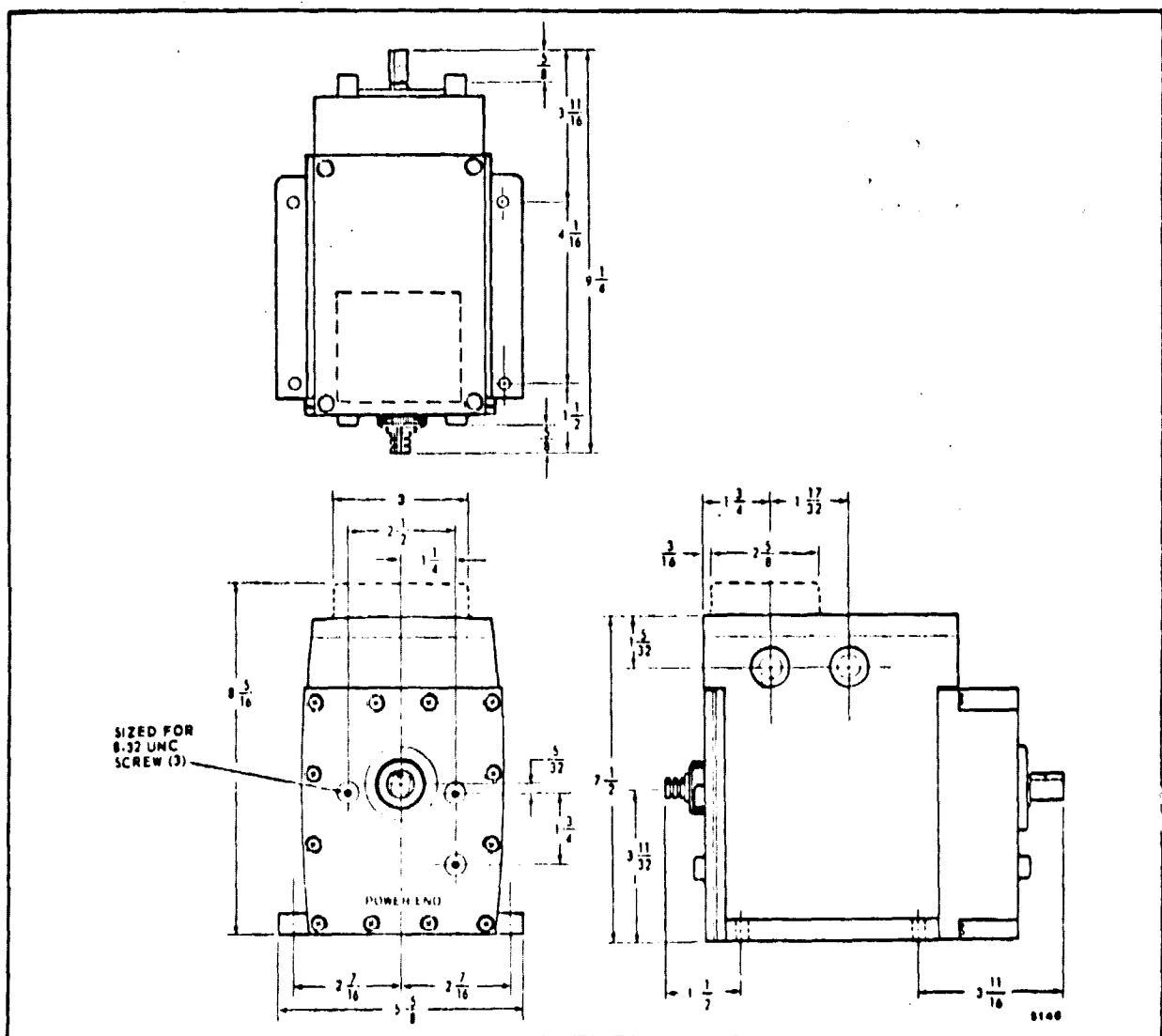
**Q618 Linkage—**connects Modutrol motor to water or steam valve.

**7640JT Weatherproofing Kits—**weatherproofs the M445 and M845 Modutrol Motors.

**7616BR Motor Crank Arm—**included with Q605 but not with motor.

**DHE 94 Explosion-proof Housing—**encloses Modutrol motor for use in explosive atmospheres. Not for use with Q601 and Q445 Linkages. Order from Crouse Hinds Co. Requires Honeywell 7617DM Coupling.

**W859A,B Economizer Controls—**provide changeover, mixed air, and minimum position controls. Mounts on top of motor.



**FIG. 1—DIMENSIONS OF M445 AND M845 MOTORS (IN INCHES). BROKEN LINES SHOW ADDITION OF COVER MOUNTED TRANSFORMER.**

# INSTALLATION

## CAUTION

1. Installer must be a trained, experienced serviceman.
2. Disconnect power supply before installation to prevent electrical shock and equipment damage.
3. All wiring must comply with applicable codes and ordinances.
4. Do not exceed the ratings given in the SPECIFICATIONS section.
5. Always conduct a thorough checkout when installation is complete.

## LOCATION

Install the Modutrol motor in any location except where acid fumes or other deteriorating vapors might attack the exposed metal parts of the motor or in atmospheres of escaping gases or other explosive mixtures. When choosing a location, allow enough clearance for mounting auxiliary equipment and servicing the motor.

## MOUNTING

### CAUTION

Do not turn the motor shaft manually or with a wrench as damage to the gear train will result.

The motor has a flange on the bottom for mounting. The mounting holes are sized for 1/4 inch machine screws or bolts. The motor may be mounted in any position as long as the shaft is horizontal.

The M445A,C,D and M845A,B,C are shipped from the factory in the closed position. The closed position is the limit of counterclockwise rotation, as viewed from the power end of the motor, with the groove in the shaft on top and the flat of the shaft 10 degrees from horizontal.

The M445B and M845E are shipped from the factory in the open position. The open position is the limit of clockwise rotation as viewed from the power end of the motor, with the groove in bottom of the shaft and the flat of the shaft 10 degrees from horizontal.

## LINKAGES

The motor comes without a crank arm. The motor crank arm is included in the Q605 Damper Linkage or may be ordered separately (Part No. 7616BR).

When planning for and installing a motor and linkage, check for the following points of operation.

1. When energized, the motor shaft must be free to travel to the end of its stroke while opening or closing a valve or damper. The motor must be stopped at the end of its stroke by the limit switch and must not be stalled by the damper or valve. This holds true even if the full energized stroke is not required to drive the valve or damper through its required stroke.

2. When de-energized, the spring returns the motor to its starting position. In some applications, it may be desirable to use a shortened stroke to provide additional force with the motor in the de-energized position, as, for example, when holding a damper closed.

In these cases, the linkage may be adjusted so that the damper closes before the motor reaches its internal mechanical limit in the de-energized mode. (Note that this applies to the de-energized mode only; the motor must always be free to travel to end of its stroke when energized.)

### CAUTION

When shortening the motor stroke in the de-energized position as described above, use extreme care in adjusting the linkage as damage to the linkage or damper may result.

3. Do not exceed load or torque ratings in any application.

## WIRING

### CAUTION

Disconnect power supply before making wiring connections to prevent electrical shock and equipment damage.

All wiring must comply with applicable codes and ordinances. Make sure that the voltage and frequency stamped on the motor correspond to the characteristics of the power supply. Do not exceed switch ratings when wiring auxiliary switches.

Wiring terminals and conduit knockouts are provided for wiring the motor. When wiring, remove top cover by removing 4 screws, replace when wiring is complete. Models with cover mounted transformer have a bracket to support the cover on motor when wiring. Multitap transformers have color-coded leads for wiring the power supply; refer to Fig. 15.

Internal schematics and typical wiring hookups are shown in Figs. 2 to 14. Note that these diagrams for M845 motors show an external transformer. On motors with a cover mounted transformer, the secondary leads are wired to the motor terminals. (If the transformer is not required, remove leads and wire 24V ac directly to the motor.)

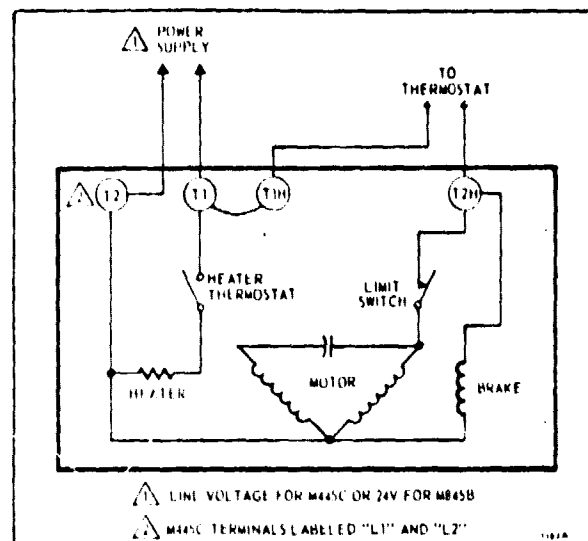


FIG. 2-INTERNAL SCHEMATIC DIAGRAM FOR THE M445C AND M845B WITH INTERNAL HEATER.

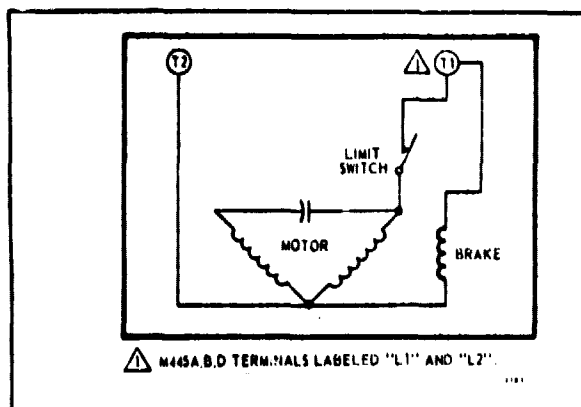


FIG. 3--INTERNAL SCHEMATIC DIAGRAM FOR M445A,B,D AND M845A,C,E.

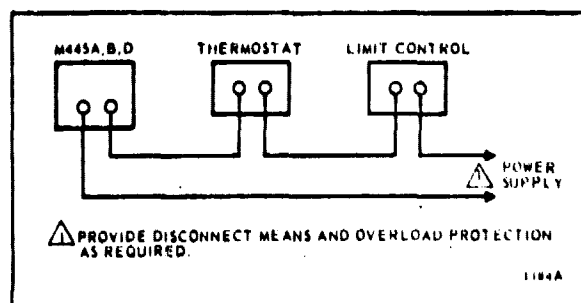


FIG. 4--CONNECTION DIAGRAM FOR M445A,B,D MODUTROL MOTORS.

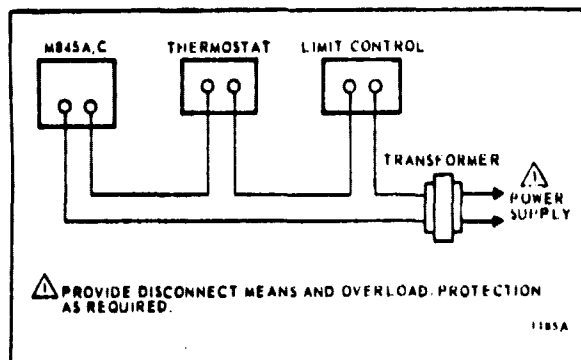


FIG. 5--CONNECTION DIAGRAM FOR M845A,C,E MODUTROL MOTORS.

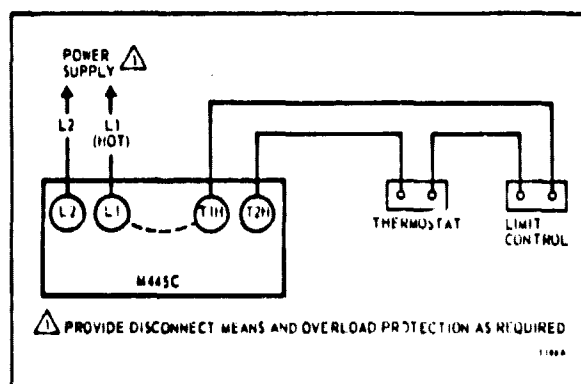


FIG. 6--EXTERNAL CIRCUIT CONNECTIONS FOR THE M445C (WITH INTERNAL HEATER).

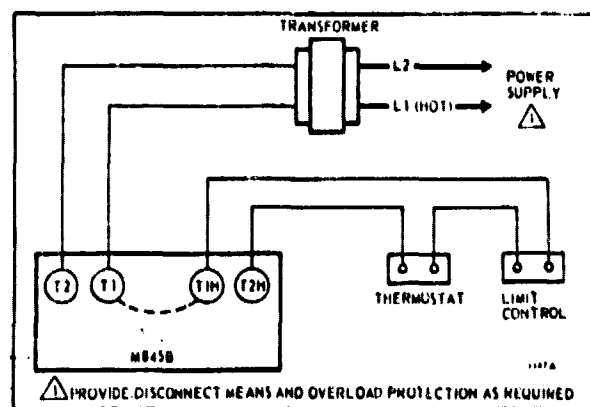


FIG. 7--EXTERNAL CIRCUIT CONNECTIONS FOR THE M845B (WITH INTERNAL HEATER).

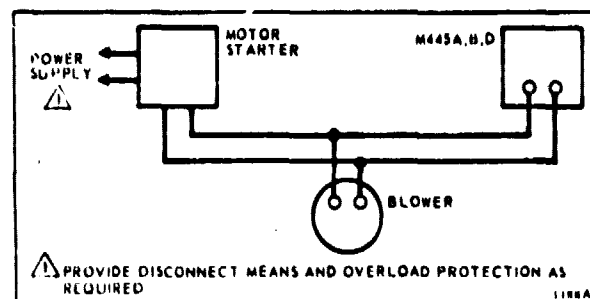


FIG. 8--POWER CONNECTION FOR M445A,B,D MODUTROL MOTORS USED TO CONTROL AIR DAMPERS.

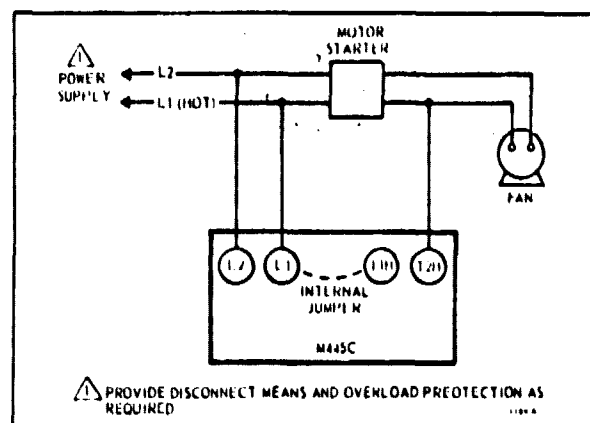


FIG. 9--M445C MODUTROL MOTOR CONNECTIONS WHEN USED TO OPEN A DAMPER ON FAN START. DAMPER CLOSING WHEN FAN STOPS.

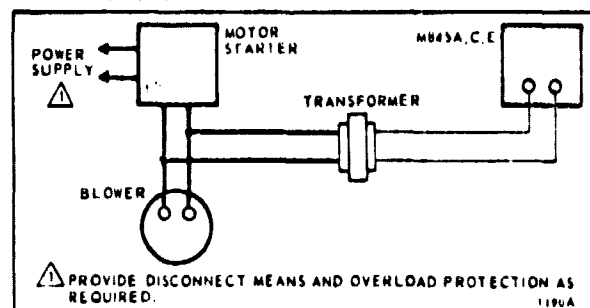


FIG. 10--POWER CONNECTION FOR THE M845A,C,E MODUTROL MOTORS USED TO CONTROL AIR DAMPERS. DAMPERS CLOSE WHEN FAN STOPS.



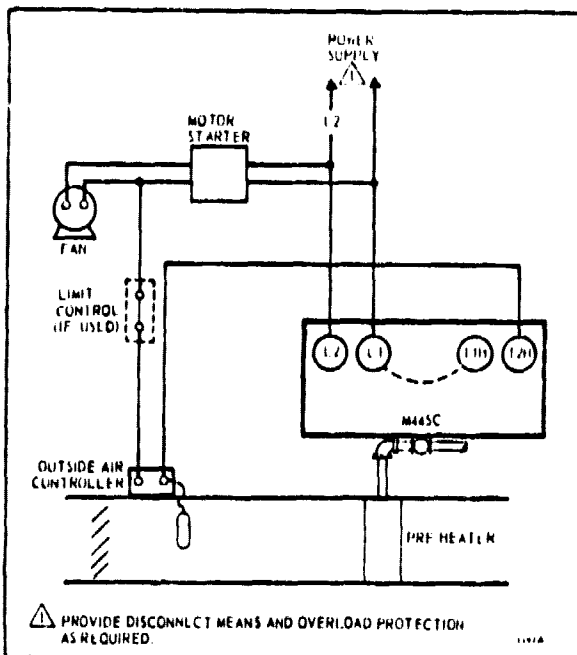


FIG. 11—WIRING DIAGRAM FOR AN M445C MODUTROL MOTOR USED TO CONTROL A PRE-HEATER COIL VALVE.

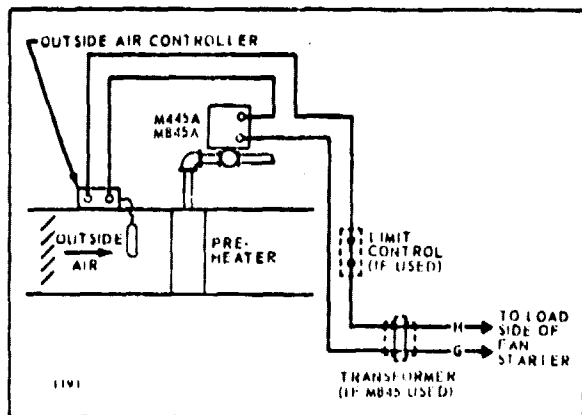


FIG. 12—WIRING DIAGRAM FOR M445 OR M845 WITHOUT INTERNAL HEATER CONTROLLING A PRE-HEATER COIL VALVE.

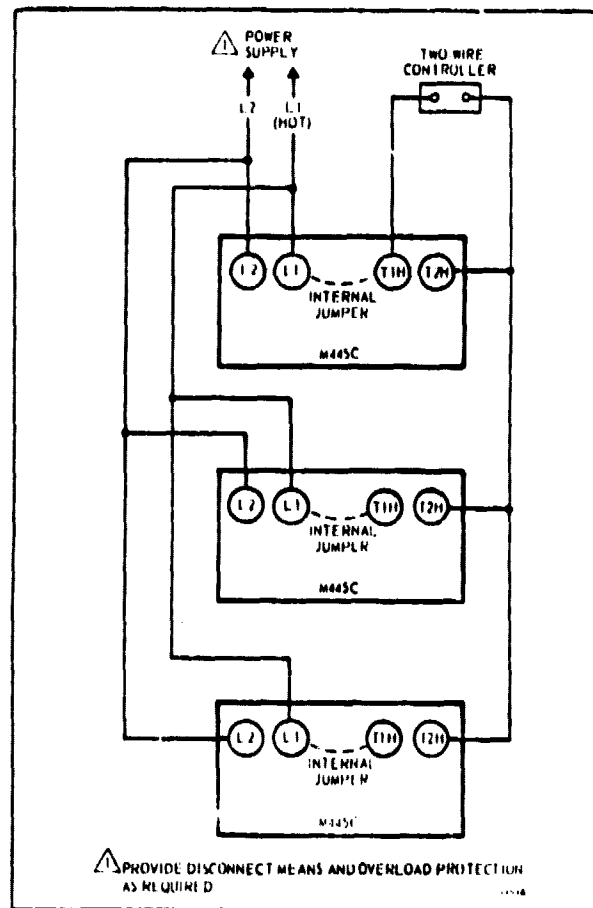


FIG. 13—THREE M445C MODUTROL MOTORS UNDER THE COMMAND OF ONE CONTROLLER.

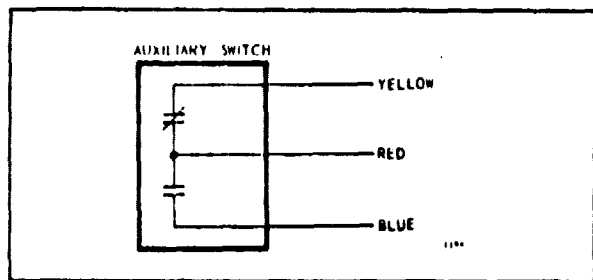


FIG. 14—AUXILIARY SWITCHES USED IN THE M445 AND M845 HAVE COLOR-CODED LEADWIRES.

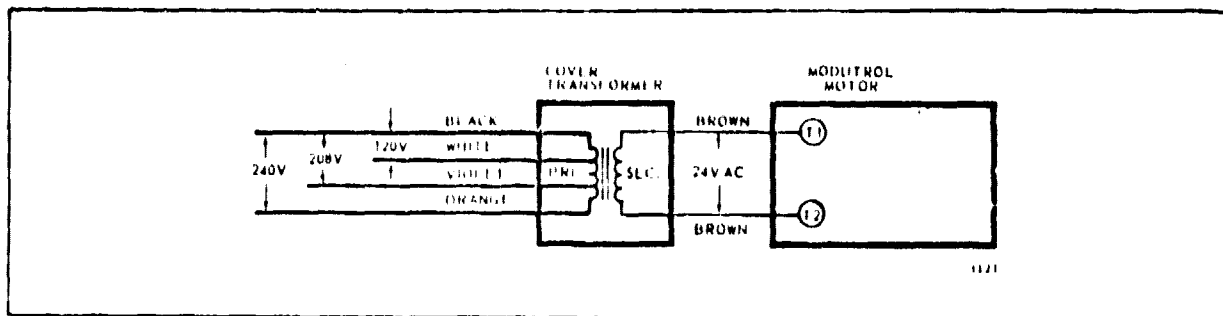


FIG. 15—WIRING DIAGRAM SHOWING COLOR-CODED LEADS FOR POWER SUPPLY CONNECTIONS.

## AUXILIARY SWITCHES

The M445 and M845 Modutrol Motors have an auxiliary switch that can be adjusted to operate at any point in the stroke of the motor. See Fig. 16. This switch may be adjusted approximately without running the motor by using the following procedure:

1. Remove the "C" clip holding the drive bracket against the spring hub. Take off the drive bracket. Refer to Fig. 18.

2. Remove the 4 screws from the corners of the return spring housing and pull the housing and spring straight out.

### CAUTION

Do not attempt to adjust or loosen the locking screw on the differential cam.

3. With the motor in the normal position, loosen the adjustment screw for the operational cam. See Fig. 17. Using the 10-degree marks on the cam and a fixed point such as the cam roller for a guide, rotate the cams clockwise (counterclockwise for normally open motors) through an arc equal to the number of degrees the motor should travel before switch operates. Tighten the operational cam adjustment screw.

4. Replace the spring and return spring housing using the 4 screws removed earlier.

5. Replace the drive bracket and "C" clip.

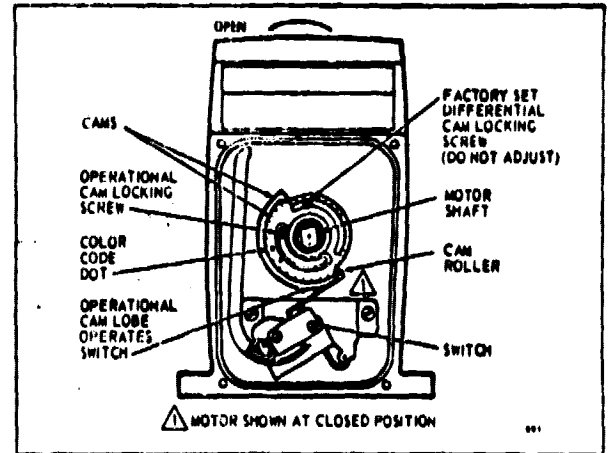


FIG. 16-LOCATION OF AUXILIARY SWITCH IN THE M445 OR M845 MODUTROL MOTOR.

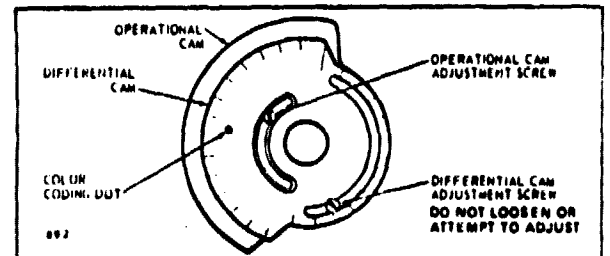


FIG. 17-SWITCH CAM MAY BE ADJUSTED TO OPERATE THE SWITCH DURING ANY PART OF THE STROKE.

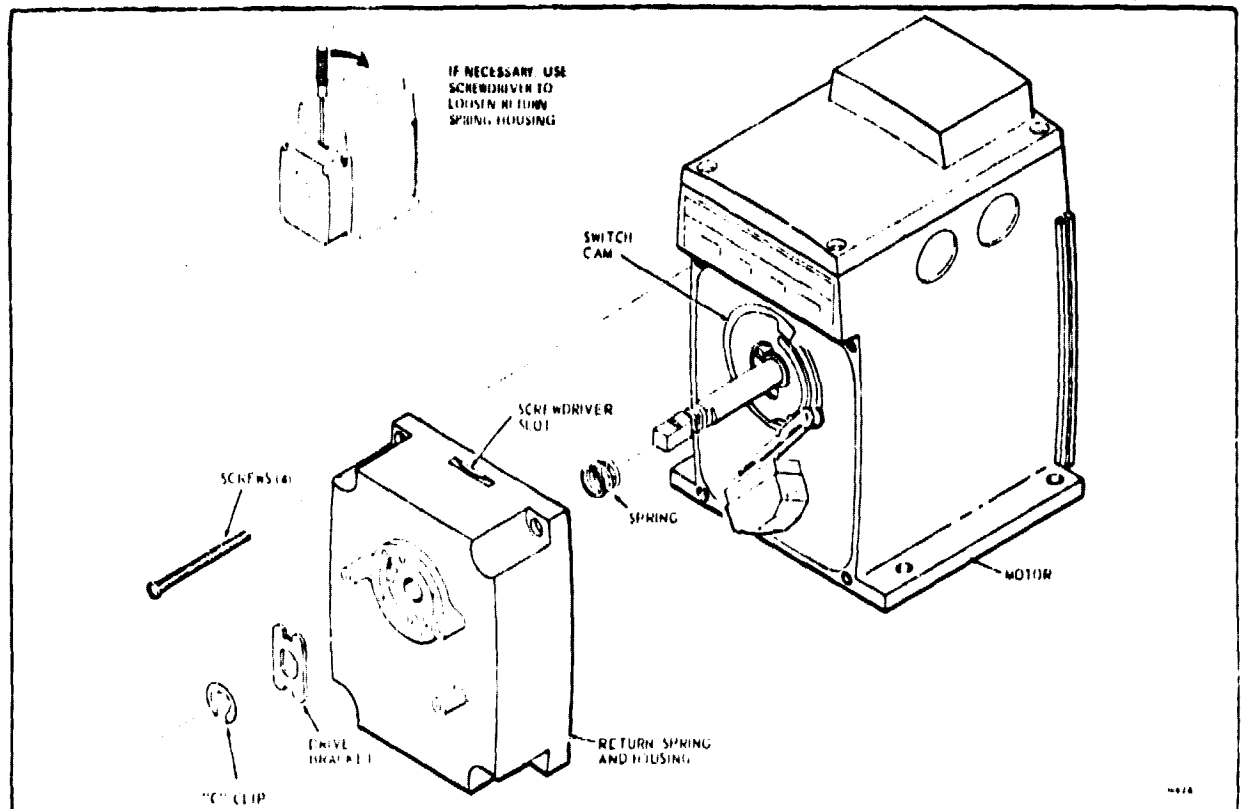


FIG. 18-REMOVING THE RETURN SPRING HOUSING TO ADJUST AUXILIARY SWITCH.

# CHECKOUT

After the installation is complete, check the entire system for the following points of operation:

1. Motor operates the load properly.
2. Motor responds properly to the controller.
3. Motor returns to the starting position when power is interrupted.

## DAMPER OPERATION

### STEP 1

Check the entire motor-damper linkage to see that the mechanical connections are secure and properly made. Make sure the ball joint on the damper crank arm is properly placed to give the required amount of travel.

### STEP 2

Energize the motor and run it to the full open position. Check the damper linkage while the motor is running to see that there are no loose or binding connections.

If the motor does not begin to run, check the control circuit for an "open" or "short," the presence of power, and the amount of power available at the motor. (The voltage at the motor must be at least 85 percent of the rated voltage on the nameplate.) Make sure that the maximum net load of the motor is not exceeded.

### STEP 3

Interrupt the power to de-energize the motor and allow the spring to return the motor to the starting position. If the motor does not return, check to see that power is actually interrupted and that the return load is not exceeding the rated motor load.

## VALVE OPERATION

### STEP 1

Check the entire motorized valve assembly to see that the mechanical connections between the motor, linkage, and valve are proper and secure. Make sure that the linkage is adjusted according to the linkage instructions. Leave the cover off the linkage until the checkout is completed.

### STEP 2

Make sure that the load does not exceed the motor rating. When using a Q601 Linkage with the motor, lubricate the bearing surfaces to prevent excessive loading. The valve packing must not be too tight. The motor actuating arm must be installed against the shoulder of the motor shaft to prevent binding at the connecting linkage bearings.

### STEP 3

Energize the motor by setting the controller so that its contacts close. The motor should start and run smoothly, and the valve stem should move to the opposite end of its stroke. If this is not the case, make sure that there is power to the motor. If there is no power, check the controller circuit for open or short circuits. If the trouble still cannot be found, measure the voltage at the source supply. Line voltage must be at least 85 percent of the rated voltage stamped on the nameplate of the motor.

### STEP 4

De-energize the motor by resetting the controller so its contacts open, or remove one of the wires from a controller terminal. Spring power should return the valve to its normal position. If this does not happen, check the linkage for binding or in the case of normally closed valves, check for fluid pressure in excess of the close-off rating.

### STEP 5

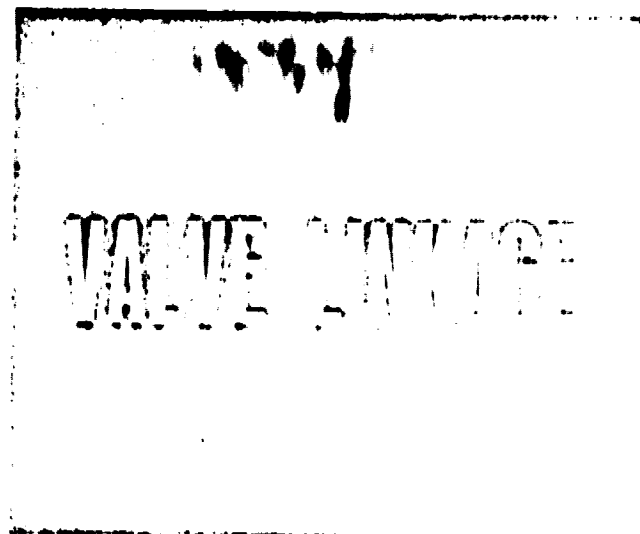
Replace the linkage cover.

# OPERATION

In an operational circuit, a single-pole, single-throw controller (line voltage for M445 or low voltage for M845) is wired in series with the motor circuit. When the controller switch closes, the motor is energized and runs to the end of its stroke. At this point, the limit switch is opened and the motor is de-energized.

The brake solenoid is energized, however, and remains so as long as the controller is closed. The brake holds the motor in the open position until the controller opens. At this point the brake is released and the spring on the motor returns it to the starting position.

# Honeywell



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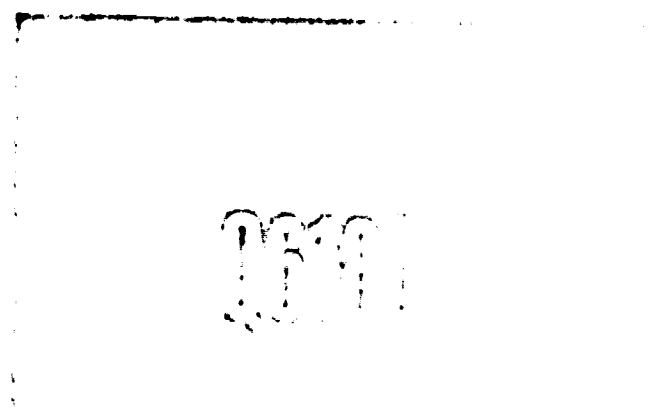
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# SPECIFICATIONS

## TRADELINE MODELS

Tradeline models are selected and packaged to provide ease of stocking, ease of handling, and maximum replacement value. Tradeline model specifications are the same as those of standard models except as noted below.

### TRADELINE MODELS:

Q618A Valve Linkage with 80 or 160 lb. seal-off force on valve stem.

ADDITIONAL FEATURES: Tradeline pack with cross reference label and special instruction sheet.

## STANDARD MODELS

MODEL: Q618A Valve Linkage.

STROKE: 3/4 inch [19 mm], fixed.

SEAL-OFF FORCE ON VALVE STEM: 80 or 160 pounds.

VALVE BONNET SIZE: 1-3/8 inches [35 mm].

TEMPERATURE RATINGS: Limited only by temperature rating of valve and motor.

WEIGHT: 3-1/2 pounds.

MOTOR REQUIRED:

160 pound—M944, M644, M941.

80 pound—M945, M445, M845, M934, M634.

MOTOR STROKE: 160 degrees—normally open or normally closed.

DIMENSIONS: See Fig. 1.

### LINKAGE REPLACEMENT INFORMATION:

OLD LINKAGES	TYPICALLY USED ON—		REPLACEMENT LINKAGES	
	VALVE	SIZE IN INCHES (MM)	STANDARD	TRADELINE
Q455C and Q601D	V5011	1/2-3 [12.5-76]	Q618A1008	Q618A1024
	V5013	1/2-3 [12.5-76]	Q618A1008	Q618A1024
	V5047 <sup>a</sup>	1-1 1/2 [25.5-38]	Q601K1003	—
	V5047	2 [51]	Q618A1008	Q618A1024
	V5051 <sup>a</sup>	2-1/2-6 [63.5-152.5]	Q601K1003	—
Q455D	V5011 <sup>a</sup>	4-6 [101.5-152.5]	Q601E1000	—
	V5013 <sup>a</sup>	4-6 [101.5-152.5]	Q601E1000	—
Q455E and Q601H	V5011 <sup>a</sup>	4-6 [101.5-152.5]	Q601F1009	—
	V5013 <sup>a</sup>	4-6 [101.5-152.5]	Q601F1009	—
Q445F and Q601G	V5011	1/2-3 [12.5-76]	Q618A1016	Q618A1032
	V5013	1/2-3 [12.5-76]	Q618A1016	Q618A1032
	V5047 <sup>a</sup>	1-1 1/2 [25.5-38]	Q601L1002	—
	V5047	2 [51]	Q618A1016	Q618A1032
	V5051 <sup>a</sup>	2-1/2-6 [63.5-152.5]	Q601L1002	—
Q455G	V5011 <sup>a</sup>	1/2-3 [12.5-76]	Q601M1001	Q601M1019
	V5013 <sup>a</sup>	1/2-3 [12.5-76]	Q601M1001	Q601M1019

<sup>a</sup>See Q601 Specification Sheet, 71-92136.

(continued on page 3)

## ORDERING INFORMATION

WHEN ORDERING REFER TO THE TRADELINE CATALOG OR PRICE SHEETS FOR COMPLETE ORDERING SPECIFICATION NUMBER, OR ...

### SPECIFY—

1. MODEL NUMBER, SPECIFY TRADELINE, IF DESIRED.
2. SEAL-OFF FORCE.

### ORDER FROM—

1. YOUR USUAL SOURCE, OR
2. HONEYWELL  
1885 DOUGLAS DRIVE NORTH  
MINNEAPOLIS, MINNESOTA 55422  
(IN CANADA—HONEYWELL CONTROLS LIMITED  
740 ELLESMERE ROAD  
SCARBOROUGH, ONTARIO)  
INTERNATIONAL SALES AND SERVICE OFFICES  
IN ALL PRINCIPAL CITIES OF THE WORLD.

# INSTALLATION

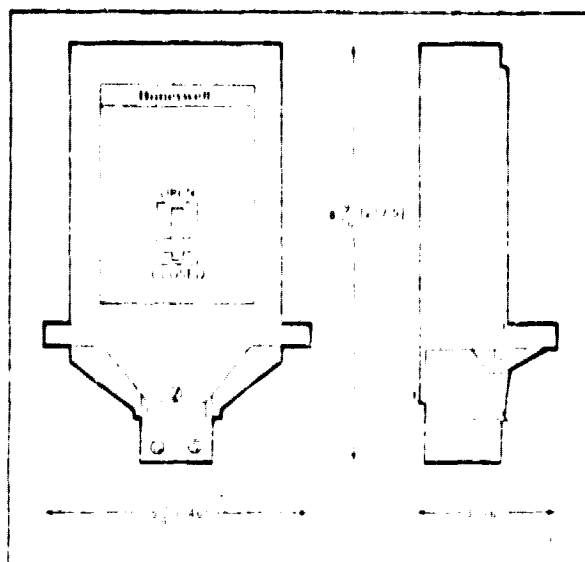


FIG. 1-Q618 INSTALLATION DIMENSIONS, IN INCHES [MILLIMETERS SHOWN IN BRACKETS].

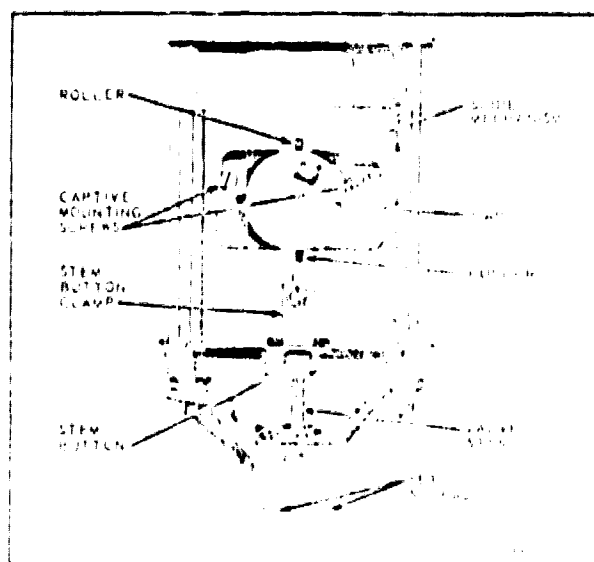


FIG. 2-INTERNAL PARTS OF THE Q618 VALVE LINKAGE.

## CAUTION

1. Installer must be a trained, experienced serviceman.
2. Disconnect power supply before beginning installation.
3. Always conduct a thorough check-out when installation is complete.

The Q618A mounts on the power end of a Modutrol motor. The linkage and motor can be rotated 360 degrees around the valve stem. The motor, however, must be installed with the shaft in a horizontal position.

Refer to the instructions packed with the valve for information on valve installation.

Wiring diagrams and other motor installation information are found in the appropriate motor instruction sheet.



FIG. 3-ASSEMBLY OF THE Q618 VALVE LINKAGE TO A MODUTROL MOTOR.

## MOUNT LINKAGE ON MOTOR

1. Remove the cover from the linkage.
2. Mount the linkage on the shaft at the power end of the motor. Note that the key on the cam must fit into the keyway on the motor shaft.
3. Use the 2 nuts provided to fasten the linkage to the base of the motor. Note that the drive mechanism will have to be compressed slightly to fit over the cam. Put the nuts on these bolts, but leave them slightly loose (tighten later).
4. Fasten the linkage to the motor with the 2 captive self-tapping screws in the linkage.
5. Tighten the 2 nuts on the motor shaft well.

## MOUNT LINKAGE AND MOTOR ON VALVE

### CAUTION

Make sure that valve is not on tripping.

1. Remove the stem button clamp.
2. Loosen, if necessary, the 2 screws and slide the linkage over the valve button (if any).
3. Tighten the 2 screws to secure the linkage and motor to the valve.

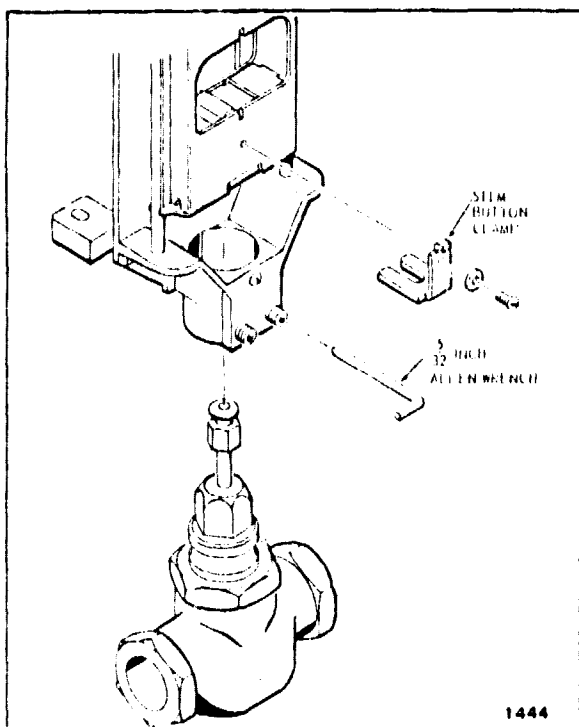


FIG. 4—ASSEMBLY OF THE LINKAGE TO THE VALVE.

### CONNECT VALVE STEM TO LINKAGE

#### NORMALLY CLOSED MOTORS

1. Place a heavy duty screwdriver under the linkage slide and into the slot in the back of the linkage (Fig. 5).
2. Use the screwdriver as a lever to force the slide mechanism up (compressing the tension relief spring)

until the stem button clamp can be fully inserted into its slot.

3. Replace and tighten the stem button clamp screw.
4. Replace the cover on the valve linkage.

#### NORMALLY OPEN MOTORS

1. Place a heavy duty screwdriver between the slide mechanism and the top of the linkage frame.
2. Use the screwdriver as a lever to force the slide mechanism down until the stem button clamp can be fully inserted into its slot.
3. Replace and tighten the stem button clamp screw.
4. Replace the cover on the valve linkage.

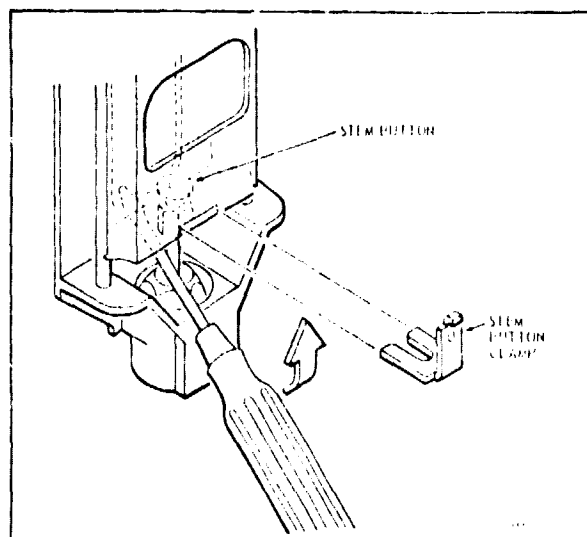


FIG. 5—THE STEM BUTTON CLAMP FASTENS THE VALVE STEM TO THE LINKAGE SLIDE MECHANISM.

## CHECKOUT

After installation has been completed, the motor linkage, and valve should be checked for the following points of operation.

1. Motor should be free to run through its complete stroke.
2. The linkage should work freely without binding.
3. The valve must close off tightly at the bottom of its stroke (both ends of stroke for 3-way valve). Check for at least  $1/32$  [.8 mm] deflection of the roller bracket in closed position (Fig. 6).

Refer to the motor instructions for motor checkout procedure.

### LUBRICATION

The Q618 Valve Linkage was lubricated at the factory and should require no additional lubrication at the time of installation. For optimum performance, the slide mechanism rollers may be lubricated yearly with a good grade of cup grease.

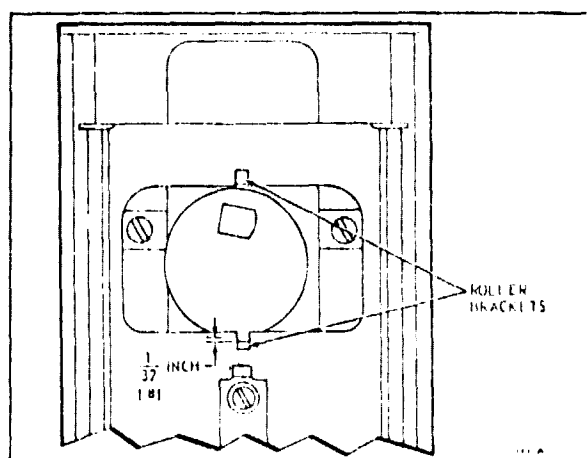


FIG. 6—FOR TIGHT CLOSE-OFF, THE ROLLER BRACKET ON THE LINKAGE MUST BE DEPRESSED AT LEAST  $1/32$  INCH [.8 MM] AT THE END OF THE MOTOR'S STROKE.

# Honeywell

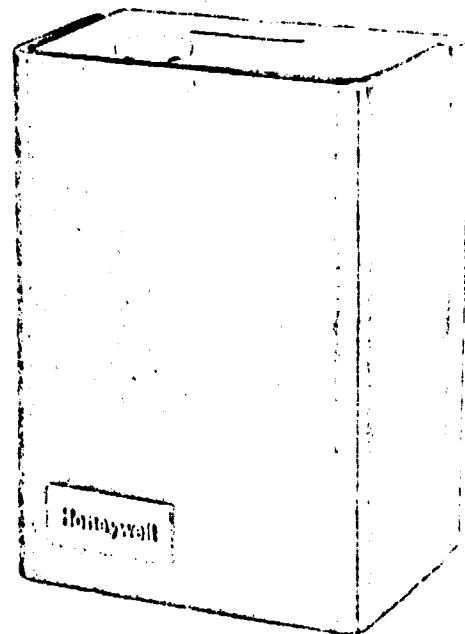
THE R7412 DIFFERENTIAL TEMPERATURE CONTROLLER PROVIDES AUTOMATIC CONTROL OF CIRCULATING PUMPS, VALVES, DAMPERS, MOTORS, AND OTHER ACCESSORIES USED IN SOLAR ENERGY SYSTEMS.

- ☐ All models contain a solid state differential temperature controller.
- ☐ R7412B,C include freeze protection.
- ☐ R7412D,E include overtemperature protection.
- ☐ R7412F includes freeze and overtemperature protection (field adjustable), and an auxiliary relay driver.
- ☐ Plug-in resistors permit changing on and off temperature differential and adapting R7412 for single function temperature control.
- ☐ R7412B-E overtemperature and freeze protection set points are selectable for factory setting, but are not field adjustable.
- ☐ Uses one or two C773 Temperature Sensors.
- ☐ Separate sensors are not required for freeze and/or overtemperature protection.

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REV. 2-78 (09)

## DIFFERENTIAL TEMPERATURE CONTROLLER



## R7412A-E

Honeywell

60-2005-2



# SPECIFICATIONS

## IMPORTANT

THE SPECIFICATIONS GIVEN IN THIS PUBLICATION DO NOT INCLUDE NORMAL MANUFACTURING TOLERANCES. THEREFORE, THIS UNIT MAY NOT MATCH THE LISTED SPECIFICATIONS EXACTLY. ALSO, THIS PRODUCT IS TESTED AND CALIBRATED UNDER CLOSELY CONTROLLED CONDITIONS, AND SOME MINOR DIFFERENCES IN PERFORMANCE CAN BE EXPECTED IF THOSE CONDITIONS ARE CHANGED.

## TRADELINE MODELS

TRADELINE MODELS are selected and packaged for ease of stocking, ease of handling, and maximum replacement value. TRADELINE specifications are the same as those of standard models except as noted below.

### TRADELINE MODEL AVAILABLE:

R7412F Differential Temperature Controller.

### TRADELINE FEATURES:

- Includes freeze and overtemperature protection and an auxiliary relay driver.
- TRADELINE Pack with cross reference label.

## STANDARD MODELS

MODEL	DIFF. TEMP. CONTROL	FREEZE PROTECTION	OVERTEMPERATURE PROTECTION	AUXILIARY RELAY DRIVER
R7412A	Yes <sup>a</sup>			
R7412B	Yes <sup>a</sup>	Yes <sup>ad</sup>		
R7412C	Yes <sup>a</sup>	Yes <sup>cd</sup>		Yes <sup>c</sup>
R7412D	Yes <sup>a</sup>		Yes <sup>bd</sup>	
R7412E	Yes <sup>a</sup>		Yes <sup>cd</sup>	Yes <sup>c</sup>
R7412F	Yes <sup>a</sup>	Yes <sup>acd</sup>	Yes <sup>bcd</sup>	Yes <sup>c</sup>

<sup>a</sup>Internal relay energizes. <sup>b</sup>Internal relay de-energizes. <sup>c</sup>Auxiliary relay energizes. <sup>d</sup>Protection setpoint is factory fixed.

### TEMPERATURE SETTING RANGES:

Control Range—0 to plus 210 F [minus 18 to plus 99 C] as defined by temperature of low temperature sensor.

Differential Temperature Controller—Adjustable ON and OFF differentials from minus 10 to plus 40 F [minus 5.6 to plus 22.2 C]. Factory-set at 18 F [10 C] temperature difference ON and 3 F [1.7 C] temperature difference OFF. Plug-in resistors vary settings (see Table 1, page 7).

Freeze Protection—

R7412B,C set point may be specified at 37, 42, or

47 F [3, 6, or 8 C], but it is factory fixed.

R7412F has field adjustable settings at 37, 42, or 47 F [3, 6, or 8 C].

Freeze differential—3 F [1.7 C].

Overtemperature Protection—

R7412D,E set point may be specified at 5 F [3.2 C] increments from 140 to 190 F [60 to 88 C], but it is factory fixed.

R7412F has field adjustable settings in 5 F [3.2 C] increments from 140 to 190 F [60 to 88 C].

Overtemperature differential—10 F [5.5 C].

(continued on page 3)

## ORDERING INFORMATION

WHEN PURCHASING REPLACEMENT AND MODERNIZATION PRODUCTS FROM YOUR TRADELINE WHOLESALE OR YOUR DISTRIBUTOR, REFER TO THE TRADELINE CATALOG OR PRICE SHEETS FOR COMPLETE ORDERING NUMBER, OR SPECIFY—

1. Differential Temperature Controller order number.
2. Temperature Sensor order number (two required).
3. Freeze protection (R7412B,C) or overtemperature protection (R7412D,E) set point desired.
4. Immersion well order number.
5. Accessories, if desired.
6. Optional specifications, if desired.

IF YOU HAVE ADDITIONAL QUESTIONS, NEED FURTHER INFORMATION, OR WOULD LIKE TO COMMENT ON OUR PRODUCTS OR SERVICES, PLEASE WRITE OR PHONE:

1. YOUR LOCAL HONEYWELL RESIDENTIAL DIVISION SALES OFFICE (CHECK WHITE PAGES OF PHONE DIRECTORY).
2. RESIDENTIAL DIVISION CUSTOMER SERVICE  
HONEYWELL INC., 1885 DOUGLAS DRIVE NORTH  
MINNEAPOLIS, MINNESOTA 55422 (612) 542-7500

(IN CANADA—HONEYWELL CONTROLS LIMITED, 740 ELLESMERE ROAD, SCARBOROUGH, ONTARIO M1P 2V9)  
INTERNATIONAL SALES AND SERVICE OFFICES IN ALL PRINCIPAL CITIES OF THE WORLD.

#### ELECTRICAL RATINGS:

Input Voltage—120V ac, 60 Hz.

Load Relay Contacts—

1 N.O. Pole—10 AFL/60 ALR at 120V ac.

1 N.C. Pole—125 VA at 120V ac.

Auxiliary Relay Drive—5 VA maximum at 24V ac, 60 Hz.

Power Consumption—7 watts maximum.

#### AMBIENT TEMPERATURE RANGE:

Controller—plus 20 to 115 F [minus 7 to plus 46 C].

Temperature Sensor—Minus 50 to plus 450 F [minus 46 to plus 232 C].

#### MOUNTING:

Controller—two screw holes in opposite corners of case. Mounting screws not included.

Electronic Temperature Sensor—Sensor is available for mounting with clip or has a flattened end with a mounting hole. Tank sensor mounts in an immersion well. See ACCESSORIES.

WIRING CONNECTIONS: 9 screw terminals. Also, 2 leadwires on R7412C,E,F.

DIMENSIONS: See Fig. 2.

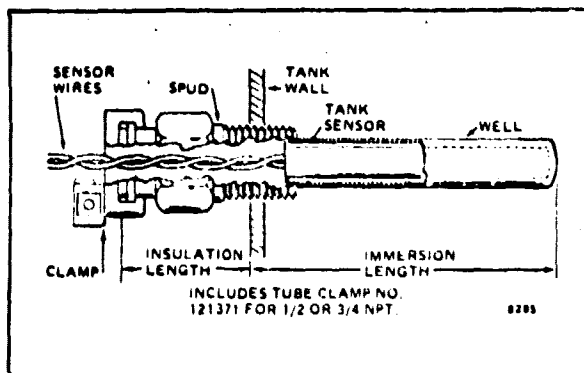


FIG. 1—TANK SENSOR INSERTED IN IMMERSION WELL.

#### AUXILIARY RELAYS:

R856A Fan Centers—

Line voltage spst and spdt switching.

Low voltage terminal strip for wiring thermostat and high side panel.

R8225A Fan Relay—spdt switching, one double throw contact.

R8225B Fan Relay—spst switching; normally open contacts.

R8225C Fan Relay—dpst switching; one normally open and one normally closed contact.

R8225D Fan Relay—dpst switching; one normally open main and one normally open auxiliary pole.

#### OPTIONAL SPECIFICATIONS:

Indicator Light—indicates when pump or fan are operating.

Auto-Off-On Switch—manual override switch which permits automatic operation of the controller or allows the controller to be switched directly ON and OFF. Switch does not affect the operation of the auxiliary relay in R7412C,E, and F.

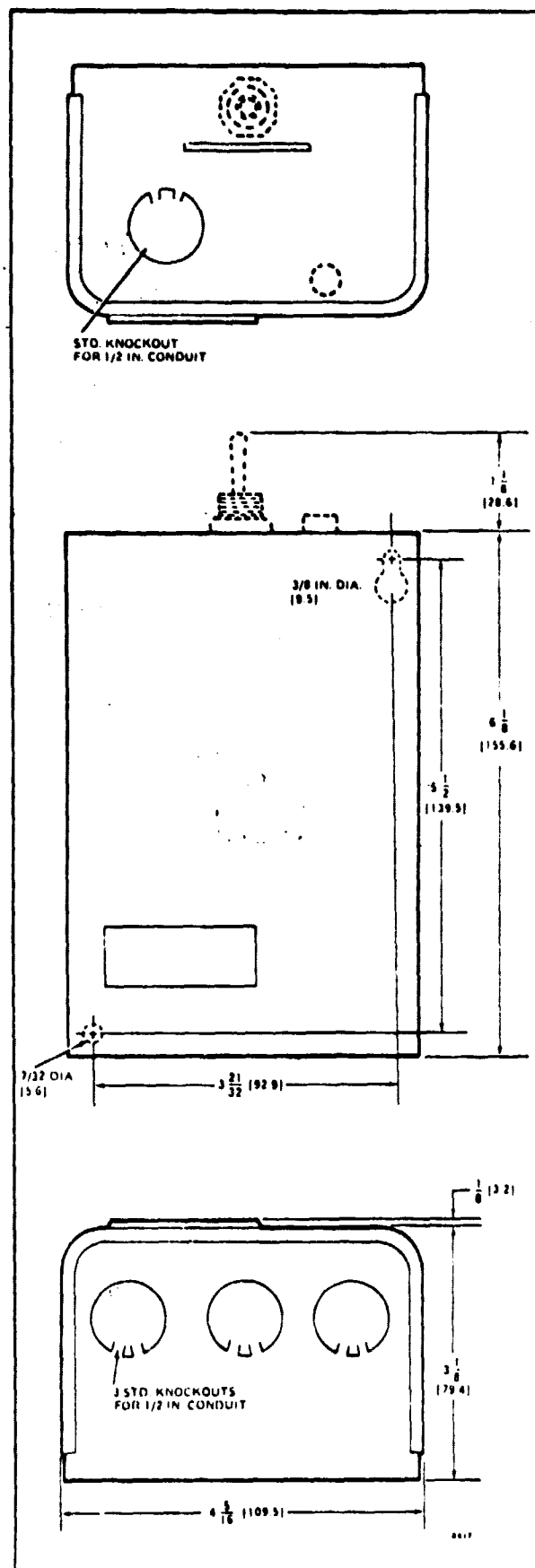


FIG. 2—R7412 MOUNTING DIMENSIONS IN INCHES [MILLIMETRES IN BRACKETS].

## ACCESSORIES:

**C773A Temperature Sensor.** Single sensor mounts in storage tank with immersion well or on collector with mounting clip.

**C773B Temperature Sensor.** Double sensor mounts in storage tank with immersion well or on collector with mounting clip.

**C773C Temperature Sensor.** Single sensor has flattened end with mounting hole for collector installation.

**C773D Temperature Sensor.** Double sensor has flattened end with mounting hole for collector installation.

**Immersion Well**--for mounting sensor in storage tank. See immersion well table and Fig. 1.

**Remote Sensor Wiring Compartment**--mounts to immersion well. Part No. 111892F.

WELL DIMENSIONS				SELECT WELL MATERIAL AND ORDER NUMBER BELOW			
INSERTION LENGTH		INSULATION LENGTH		COPPER		STAINLESS STEEL	
in	mm	in	mm	1/2 NPT	3/4 NPT	1/2 NPT	3/4 NPT
3-3/8	85.7	1-1/2		121371A	121371B	121371E	121371F
3-3/8	85.7	1-1/2			121371K <sup>a</sup>	--	--
3-3/8	85.7	3		121371L	121371M	--	--
5 3/8	85.7	4		122554B <sup>a</sup>	122555B <sup>a</sup>	--	--
3-3/8	136.5	4		122554A <sup>a</sup>	122555A <sup>a</sup>	--	--
6	152.4	1-1/4	31.8	112620BB	--	--	--

<sup>a</sup>Has plastic sleeve on insertion well.

## INSTALLATION

### CAUTION

1. Installer must be a trained, experienced service technician.
2. Disconnect power supply before connecting wiring.
3. Conduct thorough checkout when installation is complete.

### IMPORTANT

Do NOT mount collector sensor to collector fluid channels. Protect sensor from extreme temperature conditions which may be encountered when the fluid channels are drained.

### MOUNTING TEMPERATURE SENSORS

Mount tank sensor and immersion well as follows:

1. Drain system fluid to a point below the sensor fitting. (Refer to Fig. 1.)
2. Screw the well into the threaded fitting. Use an approved pipe dope or Teflon tape to seal the threads.
3. Refill system and check for leaks.
4. Insert the sensor probe into the immersion well until it bottoms.
5. Attach retainer clamp over groove on well spud. Fit wires in clamp groove and lightly tighten screw. Do not over tighten.

Mount collector sensor according to the collector manufacturers recommendations. Fasten the sensor to the panel with a No. 8 or 10 screw (Fig. 3). Do NOT mount collector sensor to collector fluid channels. Do not exceed ambient temperature ratings.

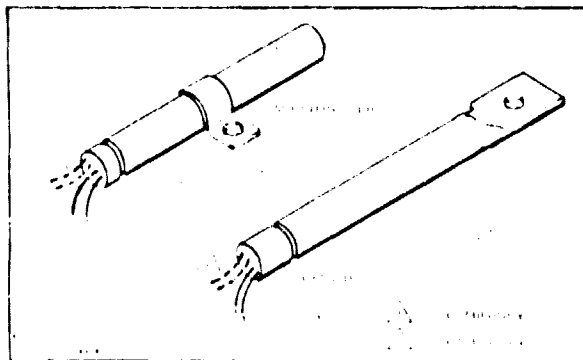


FIG. 3 MOUNTING THE C773 TEMPERATURE SENSOR.

### MOUNTING CONTROLLER

Loosen the cover screw and remove the cover. Locate the controller case on any convenient flat surface near the circulator or storage tank. Ambient temperature at location should not exceed 115 to 145 °C. Secure the controller using the 2 mounting holes located in opposite corners of the case and 2 mounting screws (not included).

## WIRING

All wiring must comply with applicable codes and ordinances. The R7412 can be used for numerous applications in solar energy systems. Refer to Figs. 4 through 7 for typical examples of R7412 hookups. Also, the OPTIONAL APPLICATIONS section depicts the R7412 using only one temperature sensor.

The temperature sensors are wired to the controller through the 1/2 inch knockout for conduit in the top of the controller case. Wire the power supply, relay contacts, and auxiliary relay driver using the three knockouts for

1/2 inch conduit in the bottom of the controller case (Fig. 1).

If the amount of sensor cable used exceeds 100 feet [30.5 m], use No. 14 wire and grounded metallic conduit or two conductor shielded cable. Connect the shield to ground at the controller. Grounded metallic conduit and shielded cable (such as Belden 8762 or equivalent) minimizes possible radio frequency signal interference.

111892F Remote Sensor Wiring Compartment is available for tank sensor wiring (see ACCESSORIES).

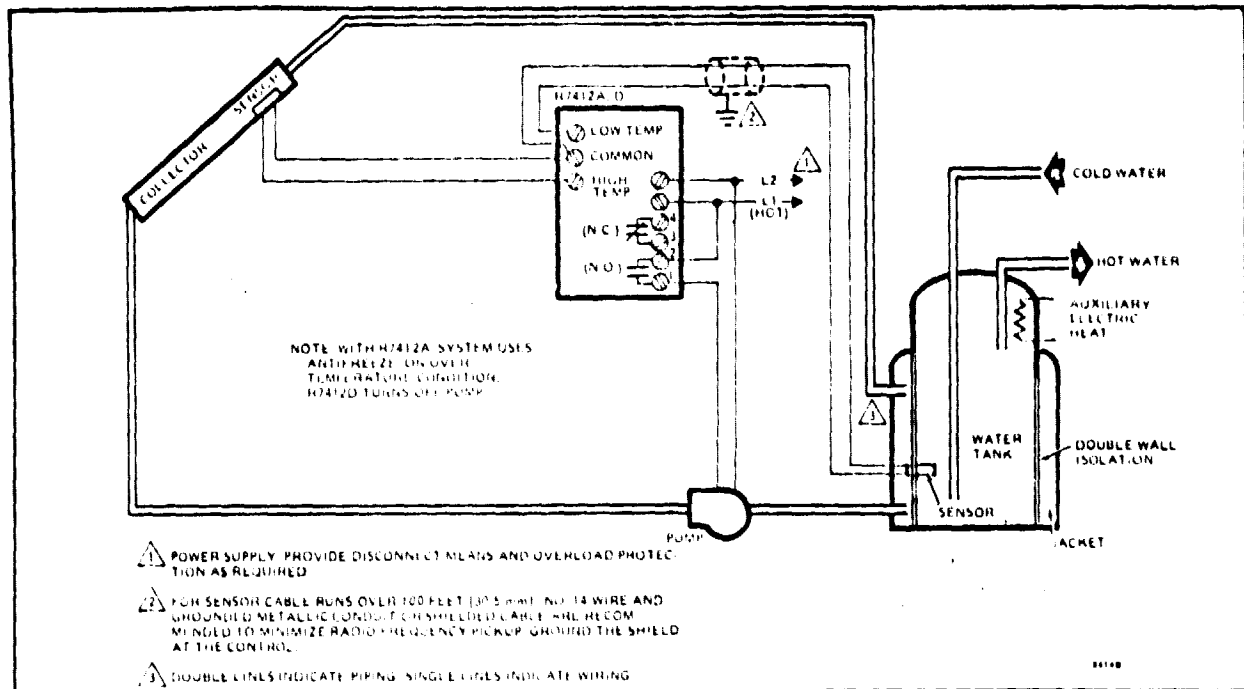


FIG. 4—USING THE R7412A,D WITH A SOLAR WATER HEATER.

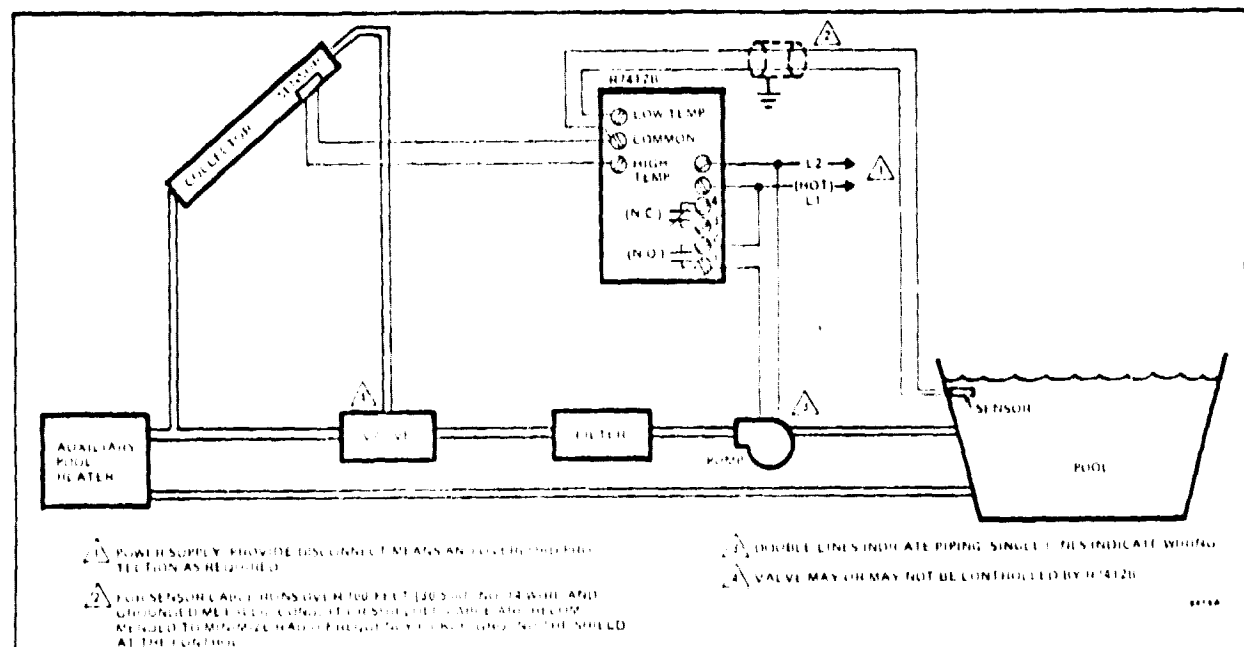


FIG. 5—USING THE R7412B WITH A SOLAR POOL HEATER. CONTROLLER ENERGIZES PUMP DURING FREEZE CONDITION.

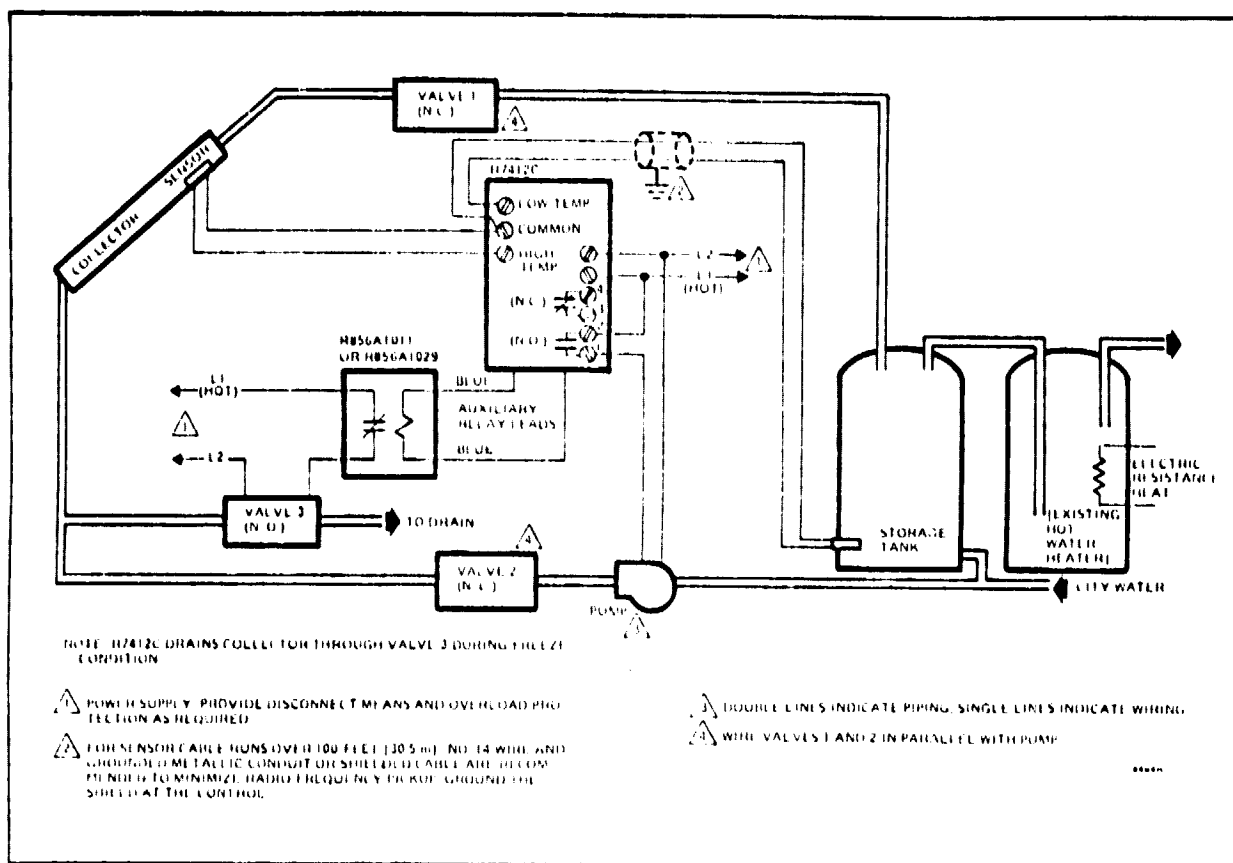


FIG. 6—INSTALLING THE R7412C IN A SOLAR HOT WATER HEATING SYSTEM.

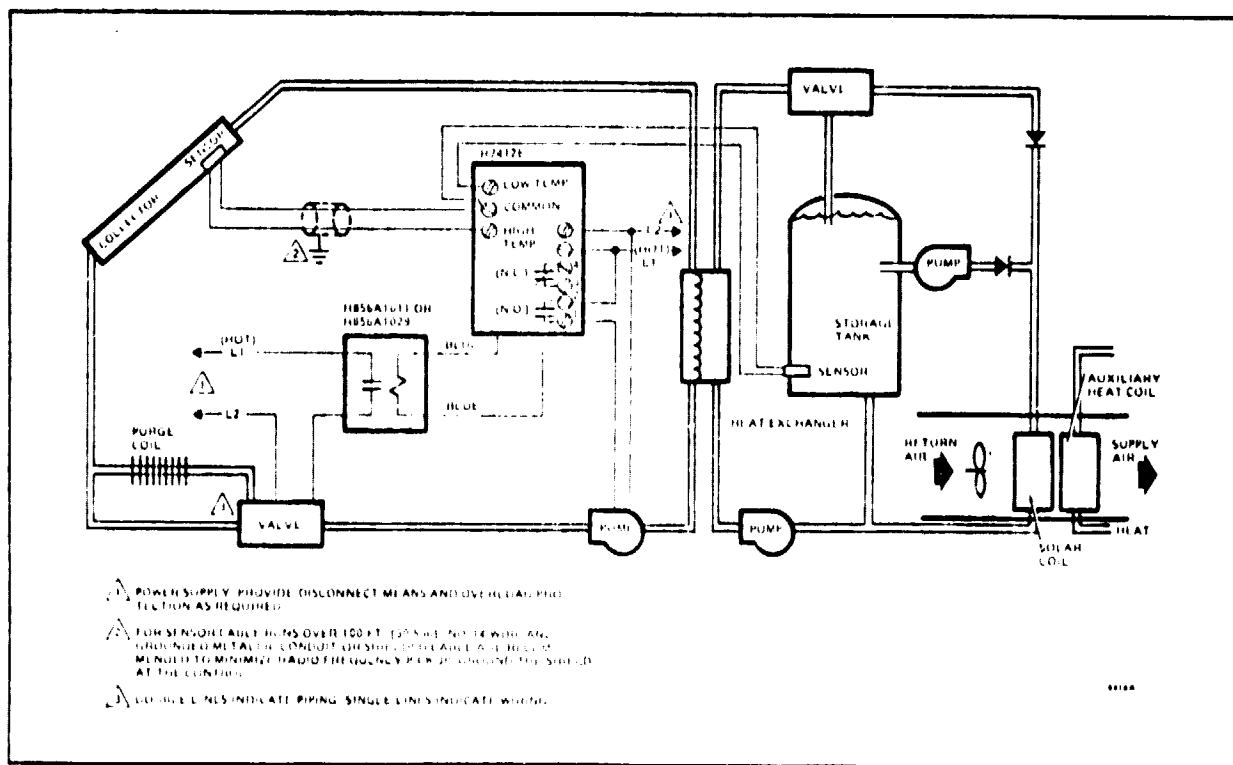


FIG. 7—TYPICAL INSTALLATION OF THE R7412E IN A SOLAR HOT WATER TO WARM AIR HEATING SYSTEM.

# ADJUSTMENTS AND CHECKOUT

## DIFFERENTIAL TEMPERATURE SELECTION

The control settings may be adjusted by changing the ON and OFF plug-in resistors (see Fig. 8). The R7412 is factory-set for pull-in at 18 F [10 C] temperature difference with a 4750 ohm ON resistor. Dropout is set for 3 F [1.7 C] temperature difference with a 9760 ohm OFF resistor.

To change either setting, refer to Table 1 to select the resistor(s) needed. See Fig. 9 to prepare resistor for installation. Remove the old resistor and plug in the replacement. Be sure the correct resistor is inserted in the proper position. Use 1/8 watt, 1 percent resistors, available locally.

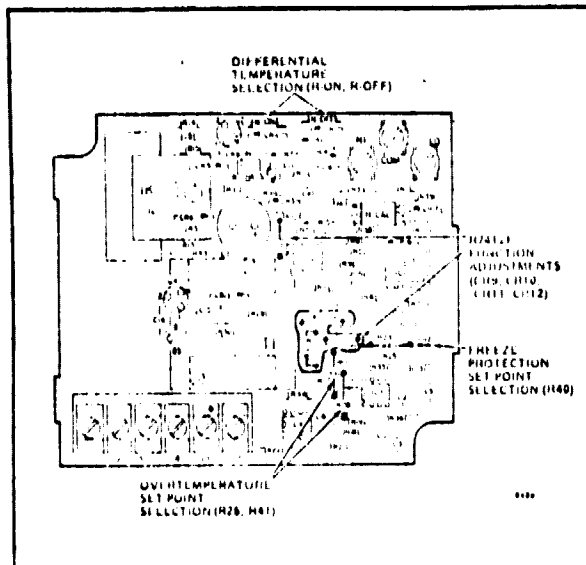


FIG. 8—ADJUSTMENT COMPONENTS OF THE R7412.

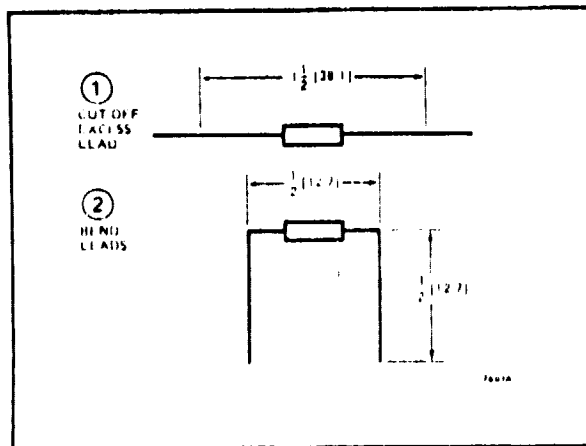


FIG. 9—PLUG-IN RESISTOR PREPARATION. DIMENSIONS IN INCHES [MILLIMETRES IN BRACKETS].

TABLE 1—ON, OFF DIFFERENTIAL TEMPERATURE CONTROL

FOR TEMPERATURE DIFFERENCE OF:		USE RESISTANCES BELOW FOR ON OR OFF RESISTORS (IN OHMS)
F	C	
-10	-6.0	27500
-5	-3.0	15400
0	0	11500
1	0.6	11000
2	1.0	10500
3	1.7	9760
4	2.2	9310
5	3.0	8870
6	3.3	8250
7	4.0	7870
8	4.4	7500
9	5.0	7150
10	6.0	6810
12	7.0	6340
14	8.0	5620
16	9.0	5230
18	10.0	4750
20 <sup>a</sup>	11.0 <sup>a</sup>	4220 <sup>a</sup>
25	14.0	3320
30	17.0	2430
35	19.0	1750
40	22.0	1210

<sup>a</sup>Maximum OFF setting must not exceed 20 F [11 C]; resistor value must be greater than 4220 ohms.

## R7412F FREEZE PROTECTION TEMPERATURE SELECTION

Freeze protection setting is adjusted by changing the freeze protection plug-in resistor, R40 (see Fig. 8). The R7412 freeze protection is factory-set at 37 F [3 C].

To change the setting to 37 F [3 C], simply remove the freeze protection resistor and leave it open circuited. For a setting of 42 F [6 C], install a 110 kilohm resistor using the resistor preparation indicated in Fig. 9. Use a 48.7 kilohm resistor to change the freeze protection setting to 47 F [8 C].

## R7412F OVERTEMPERATURE SETTING SELECTION

Overtemperature protection setting may be adjusted by changing the overtemperature protection resistors, OT1 (R41) and OT2 (R26) (see Fig. 8). The R7412 overtemperature limit is factory-set at 140 F [66 C].

To change the setting, refer to Table 2 to select the resistors needed. See Fig. 9 to prepare resistor for installation. Remove the old overtemperature resistors and insert the correct resistor in the proper position. Use 1/8 watt, 1 percent resistors, available locally.

TABLE 2—OVERTEMPERATURE CONTROL

FOR OVER-TEMPERATURE LIMIT OF:		CHANGE RESISTOR OT1 (R41) TO: (OHMS)	CHANGE RESISTOR OT2 (R26) TO: (OHMS)
F	C		
140	60	11,800	174,000
145	63	16,900	113,000
150	66	19,100	61,900
155	68	22,100	44,200
160	71	25,500	33,200
165	74	30,900	27,400
170	77	38,300	23,200
175	79	52,300	20,000
180	82	78,700	17,800
185	85	154,000	15,800
190	88	Open	14,300

### ADJUSTING FUNCTIONS OF THE R7412F

Refer to Fig. 8 for the location of the components which can be removed to change the function of the R7412F.

The R7412F can be modified to provide freeze protection through the internal relay, the auxiliary relay, both the internal and the auxiliary relay, or neither. Diodes CR9 and CR11 control these types of freeze protection. If both CR9 and CR11 remain in the controller, the internal relay will be energized as well as the auxiliary relay. Removing CR9 disables the internal relay; clipping out CR11 disables the auxiliary relay. When both CR9 and CR11 are taken out, the freeze protection feature of the R7412F is completely disabled.

Usually, CR9 or CR11 is removed to provide freeze protection which is operated by either the internal relay or the auxiliary relay, but not both.

Also, the R7412F may be adjusted to give over-temperature protection through the internal relay, the auxiliary relay, both the internal and the auxiliary relay, or neither. Diodes CR10 and CR12 control these types of overtemperature protection. If both CR10 and CR12 remain in the controller, the internal relay will be de-energized and the auxiliary relay will be energized. Removing CR10 prevents the internal relay from locking out the pump during overtemperature; clipping out CR12 disables the auxiliary relay. If both CR10 and CR12 are clipped out, the overtemperature protection capabilities of the R7412F are completely disabled.

Normally, CR10 or CR12 is clipped out to give over-temperature protection through the internal relay or auxiliary relay, but not through both.

In most cases the auxiliary relay is used for freeze protection or overtemperature protection, but not both. Therefore, CR11 or CR12 is usually removed when modifying the R7412F.

To convert the R7412F to models R7412A, B, C, D, or E use Table 3.

TABLE 3—R7412F ADJUSTMENTS

TO CONVERT R7412F TO:	CLIP OUT:	LEAVE IN:
R7412A	CR9, CR10, CR11, CR12	
R7412B	CR10, CR11, CR12	CR9
R7412C	CR9, CR10, CR12	CR11
R7412D	CR9, CR11, CR12	CR10
R7412E	CR9, CR10, CR11	CR12

## OPERATION AND CHECKOUT

### OPERATION

The controller relay contacts make when the differential temperature is greater than the ON setting and breaks when the temperature difference is less than the OFF setting.

### CHECKOUT

Check control for proper operation as follows:

1. Disconnect low temperature terminal, jumper low temperature and common terminal. Relay should pull in.

2. Remove jumper. Relay should drop out.

Observe system operation for one automatic cycle. Make certain that system comes on and turns off in response to the R7412 Differential Temperature Controller. Check for proper operation of freeze and over-temperature protection and of controlled equipment such as circulators and valves.

Shorting out the high and common terminals will simulate a freeze condition.

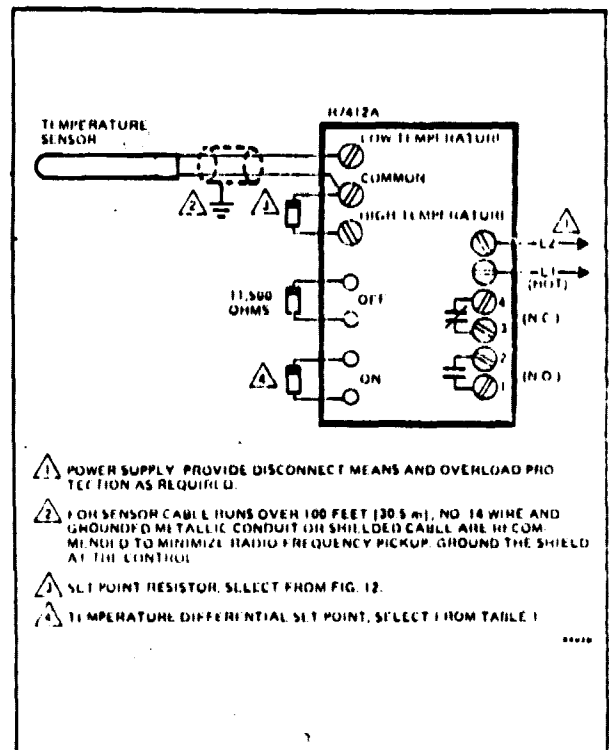
Shorting out the common and low terminals will simulate an overtemperature condition.

## OPTIONAL APPLICATIONS

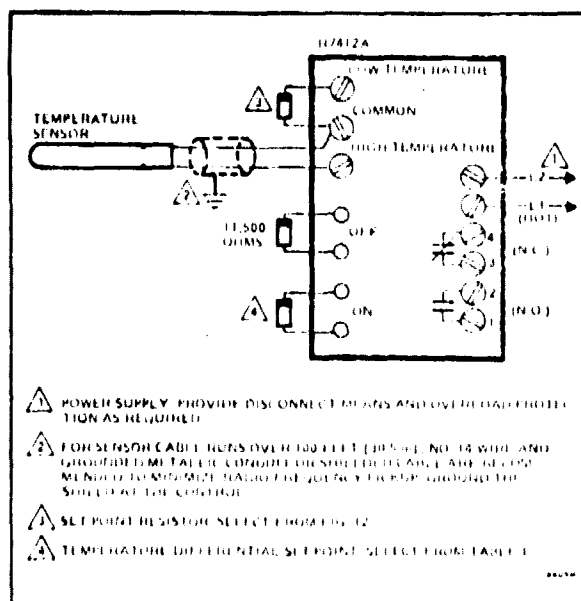
In addition to the differential temperature control, the R7412A can serve as a single function temperature controller such as a high temperature limit or an Aquastat. The R7412A is adapted to these functions by changing the ON and OFF resistors and the sensor connections. When changing functions, use 1/8 watt, 1 percent resistors, available locally.

Use the following procedures to change the factory-set differential temperature controller to a single function temperature controller as indicated in Figs. 10 and 11.

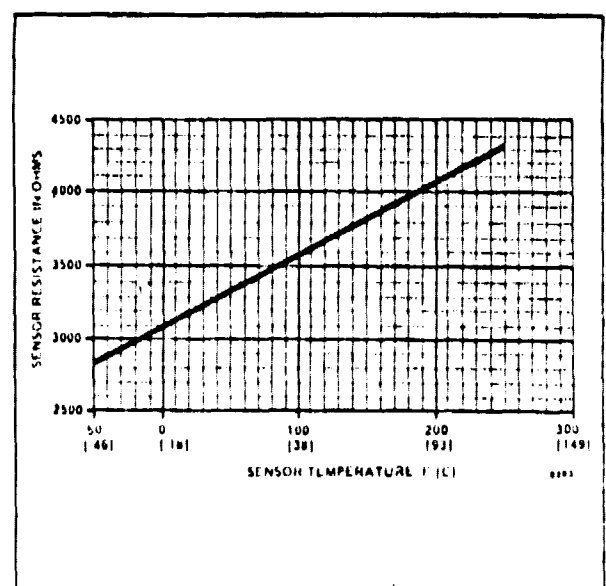
1. Remove cover. Remove the OFF resistor and replace with an 11,500 ohm resistor according to resistor preparation shown in Fig. 9.
2. To adjust the temperature differential, remove the ON resistor and select a resistor value according to Table 1. Install the selected resistor.
3. To adjust the temperature setpoint, select a resistor value according to the graph in Fig. 12. Connect the selected setpoint resistor to the low temperature and common terminals for make on temperature rise control (Fig. 10). Connect to high and common terminals for make on temperature fall.
4. Wire the sensor to the high temperature and common terminals for make on temperature rise; wire the sensor to the low temperature and common terminals on temperature fall.
5. Check the resistors for proper location and value. Replace the cover.



**FIG. 11—SINGLE FUNCTION SET POINT CONTROL. CONTROL MAKES ON TEMPERATURE FALL TO SET POINT MINUS DIFFERENTIAL, BREAKS ON TEMPERATURE RISE TO SET POINT.**



**FIG. 10—SINGLE FUNCTION SET POINT CONTROL. CONTROL MAKES ON TEMPERATURE RISE TO SET POINT PLUS DIFFERENTIAL, BREAKS ON TEMPERATURE FALL TO SET POINT.**



**FIG. 12—R7412A SINGLE FUNCTION TEMPERATURE SET POINT. CHOOSE A RESISTANCE ACCORDING TO THE DESIRED SET POINT**



# Honeywell

THE T675 AND T678 TEMPERATURE CONTROLLERS REGULATE THE TEMPERATURE OF AIR OR LIQUIDS IN DUCTS, PIPES, TANKS, AND BOILERS. TYPICAL USES INCLUDE CONTROL OF DAMPERS AND VALVES IN HEATING, COOLING, OR HEATING-COOLING SYSTEMS.

□ T675A has 1 single-pole, double-throw (spdt) switch that breaks R-B and makes R-W at the set point on a temperature rise.

□ T675B has 1 single-pole, single-throw (spst) switch that breaks at the set point on a temperature fall, and requires manual resetting.

□ T678A has 2 single-pole, double-throw (spdt) switches that operate in sequence. The right switch breaks R-B and makes R-W at the set point on a temperature rise. The left switch breaks R-B and makes R-W if the temperature continues to rise through the interstage differential.

□ T675A models available with an adjustable differential.

□ T675A and T678A have set point adjustment knob on front of case.

□ T675B has manual reset button on front of case.

□ Capillary tubing allows remote mounting of sensing element; models available with various lengths.

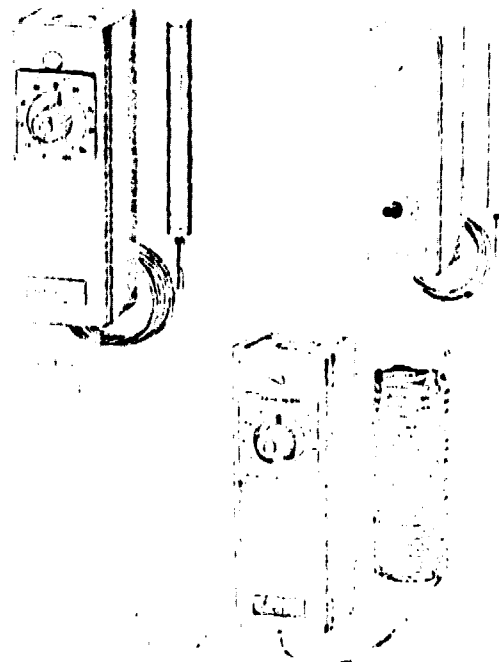
□ T675A and T678A models available with a fast-response sensing element.

□ Controller can be mounted in any position.

□ Mounting accessories available for all applications.

J.B.  
REV. 7-78 (08)

## TEMPERATURE CONTROLLERS



T675A  
T675B  
T678A

ORIGINAL PAGE IS  
OF POOR QUALITY

# SPECIFICATIONS

## IMPORTANT

THE SPECIFICATIONS GIVEN IN THIS PUBLICATION DO NOT INCLUDE NORMAL MANUFACTURING TOLERANCES. THEREFORE, THIS UNIT MAY NOT MATCH THE LISTED SPECIFICATIONS EXACTLY. ALSO, THIS PRODUCT IS TESTED AND CALIBRATED UNDER CLOSELY CONTROLLED CONDITIONS, AND SOME MINOR DIFFERENCES IN PERFORMANCE CAN BE EXPECTED IF THOSE CONDITIONS ARE CHANGED.

## TRADELINE MODELS

TRADELINE models are selected and packaged to provide ease of stocking, ease of handling, and maximum replacement value. TRADELINE model specifications are the same as those of standard models except as noted below.

### TRADELINE MODELS AVAILABLE:

T675A and T678A Temperature Controllers—see Table I for TRADELINE models available.

CAPILLARY: 5 feet [1.5 metres] long, copper (except 1 T675A model with a 20 foot [6.1 metre] capillary).

### TRADELINE FEATURES:

- All TRADELINE Models include a 107324A Capillary Holder, except those with a fast-response sensing element—which include a 131524A Capillary Holder.
- TRADELINE pack with cross reference and special instruction sheet.

TABLE I—TRADELINE MODELS AVAILABLE

MODEL	DIFFERENTIAL	OPERATING TEMPERATURE RANGE (SCALE RANGE)		MAXIMUM SAFE BULB TEMPERATURE	
		F	C	F	C
T675A (1 spdt switch)	Adjustable 3 to 10 F [1.7 to 5.6 C]	0 to 100 <sup>a,b</sup>	-18 to + 38	125	52
	Adjustable 3.6 to 12 F [2.0 to 6.7 C]	160 to 260	71 to 127	280	138
	Fixed at 1 F [0.6 C]	55 to 175 <sup>a</sup>	13 to 79	200	93
T678A (2 spdt switches)	Each switch: Fixed at 3 F [1.7 C] Interstage: Adj. 3 to 10 F [1.7 to 5.6 C]	0 to 100 <sup>a</sup>	-18 to + 38	125	52
	Each switch: Fixed at 3.6 F [2.0 C] Interstage: Adj. 3.6 to 12 F [2.0 to 6.7 C]	55 to 175 <sup>a</sup>	13 to 79	200	93

<sup>a</sup>TRADELINE model also available with a fast-response sensing element, including a 131524A Capillary Holder.

<sup>b</sup>TRADELINE model also available with a 20 foot [6.1 metre] copper capillary.

## ORDERING INFORMATION

WHEN PURCHASING REPLACEMENT AND MODERNIZATION PRODUCTS FROM YOUR TRADELINE WHOLESALER OR YOUR DISTRIBUTOR, REFER TO THE TRADELINE CATALOG OR PRICE SHEETS FOR COMPLETE ORDERING NUMBER, OR SPECIFY—

1. Order number; specify TRADELINE model, if desired.
2. Operating temperature range (scale range).
3. Standard sensing bulb or fast-response sensing element (if available).

4. Capillary length and material.
5. Fixed or adjustable differential on a T675A.
6. Differential range on adjustable T675A and T678A models.
7. Replacement parts, if desired.
8. Accessories, if desired.

IF YOU HAVE ADDITIONAL QUESTIONS, NEED FURTHER INFORMATION, OR WOULD LIKE TO COMMENT ON OUR PRODUCTS OR SERVICES, PLEASE WRITE OR PHONE:

1. YOUR LOCAL HONEYWELL RESIDENTIAL DIVISION SALES OFFICE (CHECK WHITE PAGES OF PHONE DIRECTORY).
2. RESIDENTIAL DIVISION CUSTOMER SERVICE  
HONEYWELL INC., 1885 DOUGLAS DRIVE NORTH  
MINNEAPOLIS, MINNESOTA 55422 (612) 642-7500

(IN CANADA—HONEYWELL CONTROLS LIMITED, 740 ELLESMERE ROAD, SCARBOROUGH, ONTARIO M1P 2V9)  
INTERNATIONAL SALES AND SERVICE OFFICES IN ALL PRINCIPAL CITIES OF THE WORLD.

## STANDARD MODELS

MODELS (also refer to Table II):

**T675A** Temperature Controller—spdt switching to make or break a circuit on a temperature change; fast-response models operate approximately 4 times faster than standard models.

**T675B** Low Limit Temperature Controller—spst

switching to break a circuit on a temperature fall, must be manually reset.

**T678A** Temperature Controller—2 spdt switches operate 2 independent circuits in sequence; fast-response models operate approximately 4 times faster than standard models.

TABLE II—STANDARD MODELS AVAILABLE

MODEL	SNAP-ACTING SWITCHES	DIFFERENTIAL <sup>a</sup>	OPERATING TEMPERATURE RANGE (SCALE RANGE)		MAXIMUM SAFE BULB TEMPERATURE	
			F	C	F	C
T675A	one spdt	Adjustable 3 to 10 F [1.7 to 5.6 C]	0 to 100 <sup>c</sup>	-18 to + 38	125	52
			160 to 260	71 to 127	280	138
		Adjustable 3.6 to 12 F [2.0 to 6.7 C]	55 to 175 <sup>c</sup>	13 to 79	200	93
			0 to 100	-18 to + 38	125	52
		Fixed at 1 F [0.6 C]	55 to 175 <sup>d</sup>	13 to 79	200	93
			160 to 260	71 to 127	280	138
T675B	one spst	Manual reset <sup>b</sup>	30 to 50 <sup>e</sup>	- 1 to + 10	125	52
T678A	two spdt	Each switch: Fixed at 3 F [1.7 C] Interstage: Adjustable 3 to 10 F [1.7 to 5.6 C]	0 to 100	-18 to + 38	125	52
			160 to 260	71 to 127	280	138
		Each switch: Fixed at 3.6 F [2.0 C] Interstage: Adjustable 3.6 to 12 F [2.0 to 6.7 C]	0 to 100 <sup>f</sup>	-18 to + 38	125	52
			55 to 175	13 to 79	200	93

<sup>a</sup>All differentials are subtractive except for the T675B (which has manual reset) and the interstage differential on T678A models.

<sup>b</sup>Temperature should rise 10 degrees F [5.6 degrees C] above the set point before resetting.

<sup>c</sup>Model available with dual scale (marked in both Fahrenheit and Celsius).

<sup>d</sup>Model available with a fast-response sensing element, including a 131524A Capillary Holder.

<sup>e</sup>Factory-set and locked at 37 F [3 C].

<sup>f</sup>Sensing element is a 12 ft [3.7 m] averaging element on the end of a 10 ft [3.0 m] copper capillary.

### ELECTRICAL RATINGS:

T675A models with adjustable differential and T678A:

	120V AC	240V AC
Full Load Amp	8.0	5.1
Locked Rotor Amp	48.0	30.6

T675A models with fixed differential—125 VA at 120/208/240V ac.

T675B—125 VA pilot duty up to 240V ac.

T678A—maximum connected load—2000 VA.

OPERATING TEMPERATURE RANGE (SCALE RANGE): See Table II.

DIFFERENTIAL: See Table II.

### ADJUSTMENTS:

Set Point (Operating Temperature):

T675A and T678A—adjustment knob on dial on front of controller.

T675B—screwdriver slot in center of dial (cover must be removed).

Differential (cover must be removed):

T675A models with adjustable differential—adjustment dial on snap-acting switch.

T678A interstage differential—star wheel on left side of chassis.

MAXIMUM AMBIENT OPERATING TEMPERATURE (CONTROLLER CASE): 125 F [52 C].

(continued on page 4)

B-63

## LOCATION AND MOUNTING

The controller may be installed in any convenient position. Mount it with 3 screws through the slotted holes in the back of the case (Fig. 1). Be sure to consider the length of the capillary before mounting the controller.

Install the sensing element where it is exposed to the average temperature of the controlled medium. The sensing bulb may be directly immersed or mounted in a well. T675A or T678A fast-response models must use the capillary holder furnished with the device (Fig. 2). The remote sensing bulb of standard models should be held in place with a capillary holder, immersion well, or compression fitting (Figs. 3-5). Sharp bends or kinks in the capillary tubing affect the efficiency of the controller and must be avoided. Excess capillary should be carefully coiled and left directly beneath the controller.

**NOTE:** When pressure fittings are used in areas of vibration, such as pipe lines, the bulb must be adequately supported.

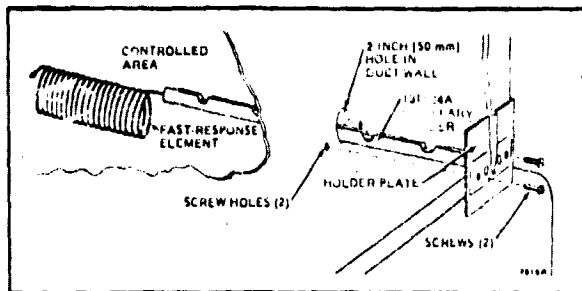


FIG. 2—MOUNTING A FAST-RESPONSE ELEMENT IN AN AIR DUCT.

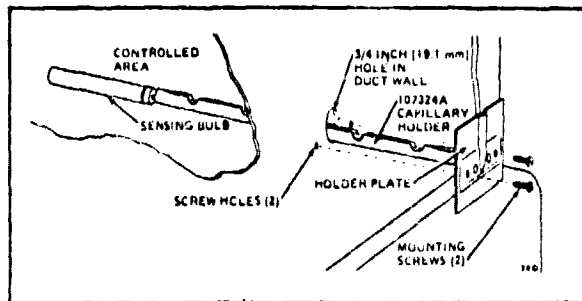


FIG. 3—MOUNTING THE SENSING BULB AND CAPILLARY HOLDER IN AN AIR DUCT.

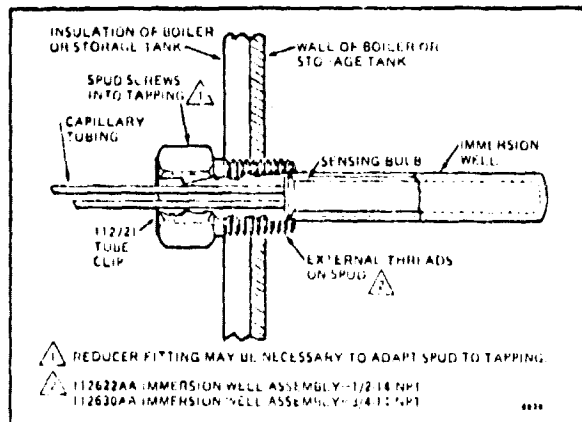


FIG. 4—MOUNTING THE SENSING BULB IN AN IMMERSION WELL.

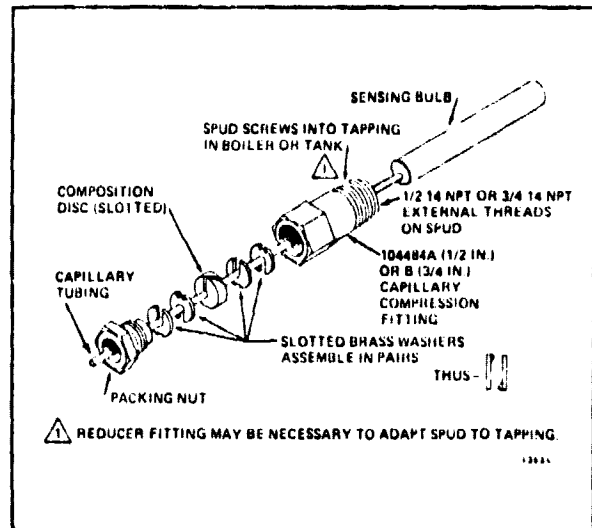


FIG. 5—MOUNTING THE SENSING BULB USING A CAPILLARY COMPRESSION FITTING.

## WIRING

Disconnect the power supply before making wiring connections to prevent electrical shock and equipment damage. All wiring must comply with applicable electrical codes, ordinances, and regulations. If using the controller with a flame safeguard control, use moisture-resistant No. 14 wire suitable for at least 167 F [75 C] for a primary control (such as an RA890), or for at least 194 F [90 C] for a programming control (such as an R4140). For high temperature installations, use moisture-resistant No. 14 wire selected for a temperature rating above the maximum operating temperature.

Two knockouts for 1/2 inch conduit are provided—one in the top and one in the bottom of the case. Follow the wiring instructions furnished with the heating or cooling system. Fig. 6 shows the switching action.

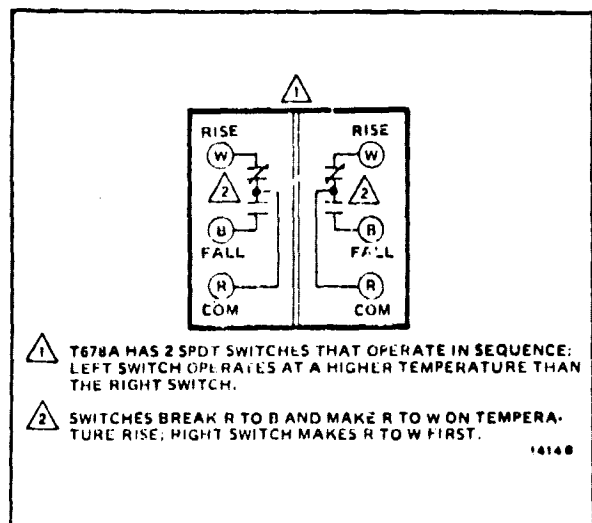


FIG. 6—T678A SWITCHING ACTION. T675A IS SIMILAR, BUT IT HAS ONLY ONE SPDT SWITCH. T675B HAS ONE SPST SWITCH THAT OPENS ON TEMPERATURE FALL.

# OPERATION

## T675A

As the temperature of the controlled medium falls below the set point less differential, the T675A switch makes terminals R to B and energizes a normally closed solenoid valve to provide heat. In cooling applications, the T675A makes terminals R to W as the temperature rises above the set point, energizing cooling equipment. Fig. 7 shows the operation of the T675A. Fig. 8 shows the location of the adjustment dial on models with an adjustable differential.

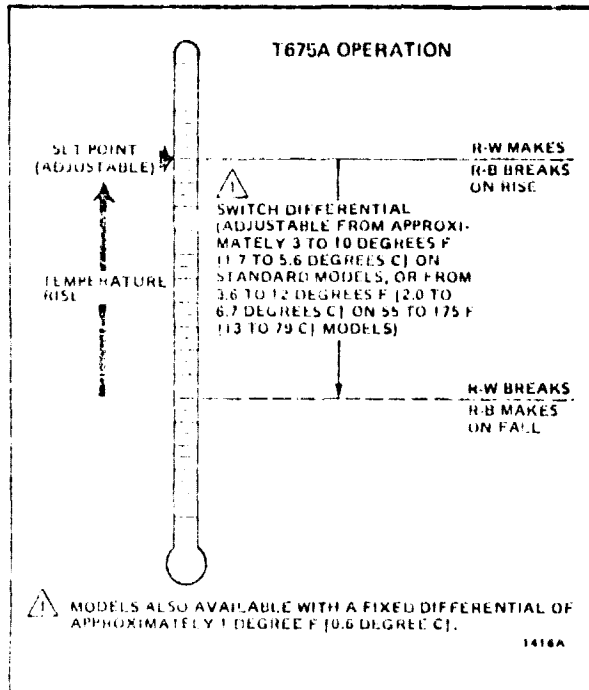


FIG. 7—OPERATION OF THE T675A.

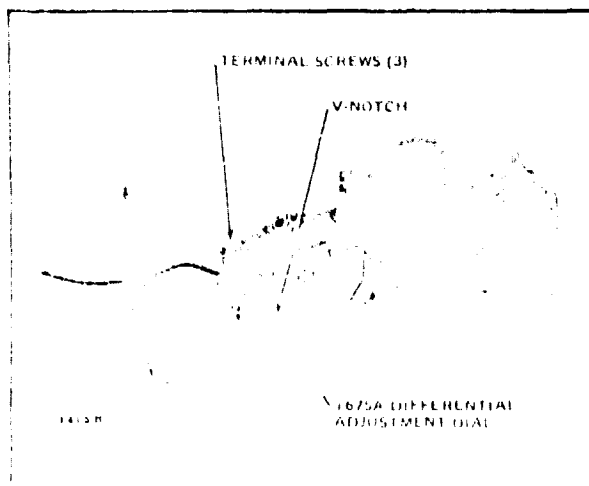


FIG. 8—LOCATION OF THE ADJUSTMENT DIAL ON T675A MODELS WITH AN ADJUSTABLE DIFFERENTIAL.

## FREEZE-UP PROTECTION

When using the T675A (auto-recycling) for freeze-up protection, the recommended set point is 38 F [3.3 C] plus the switch differential.

Example: Set point of 38 F [3.3 C] plus 1 degree F [0.6 degree C] (fixed differential model) equals an actual set point of 39 F [3.9 C].

Example: Set point of 38 F [3.3 C] plus 3 degrees F [1.7 degrees C] (adjustable differential model) equals an actual set point of 41 F [5 C].

This provides an adequate safety factor for freeze-up protection.

NOTE: The T675B is a manual reset device specifically designed for freeze-up protection.

## T675B

Used as a low limit controller, the T675B interrupts the operation of equipment if the temperature of the controlled medium falls below the set point. The device is reset manually after a rise in temperature of approximately 10 degrees F [5.6 degrees C]. The operation of the T675B is shown graphically in Fig. 9.

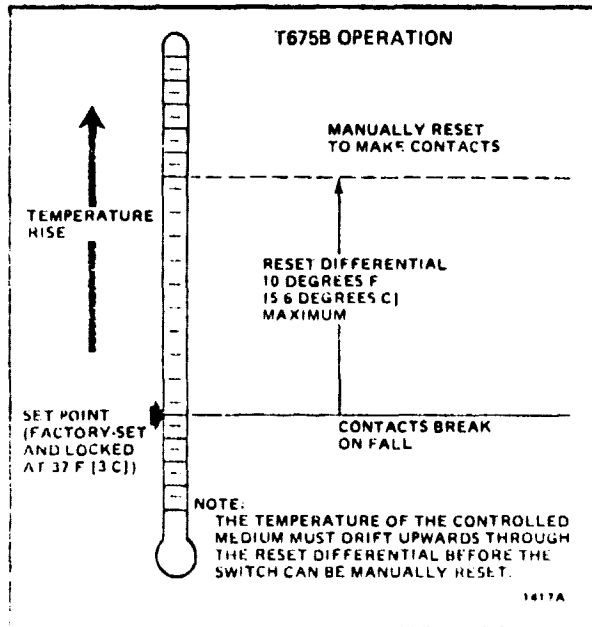


FIG. 9—OPERATION OF THE T675B.

## T678A

When the temperature at the sensing element rises above the set point of the controller, the switch on the right makes R-W. Should the temperature continue to rise through the preselected interstage differential of the controller, the switch on the left will make R-W.

Conversely, on a temperature fall, the switch on the left makes R-B, providing first step switching. If the temperature continues to fall, the switch on the right makes R-B to provide sequencing of equipment.

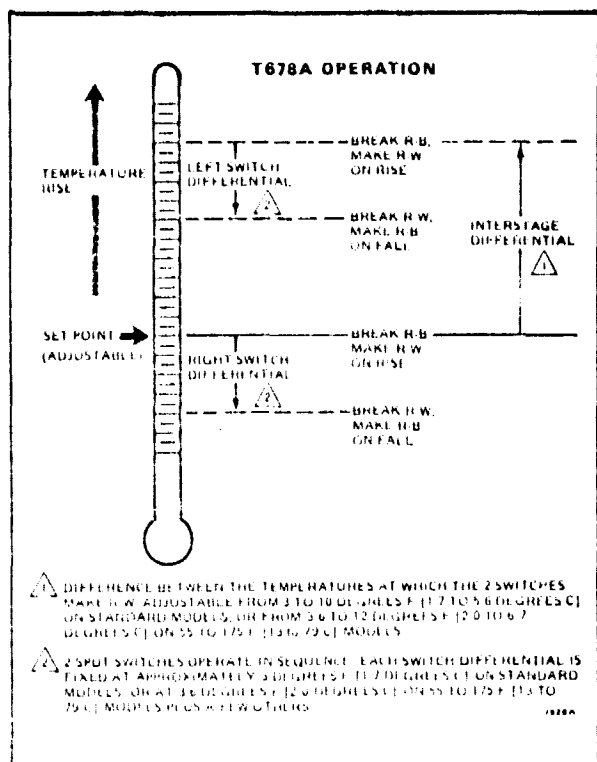


FIG. 10—OPERATION OF THE T678A.

The T678A Temperature Controller has an adjustable interstage differential. The set point adjustment knob determines the temperature at which the right switch operates. The left switch can be adjusted to operate from 3 to 10 degrees F [1.7 to 5.6 degrees C] (or 3.6 to 12 degrees F [2.0 to 6.7 degrees C] on some models) above the point of operation of the right switch. An illustration depicting the operation of the T678A is shown in Fig. 10. The interstage differential is adjusted by turning the star wheel with a narrow screwdriver inserted into the rectangular hole in the chassis (Fig. 11).

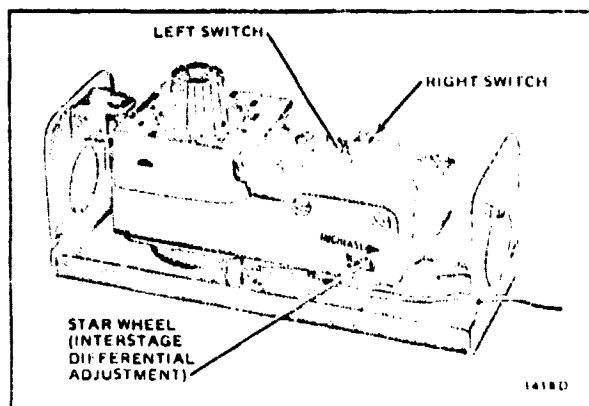


FIG. 11—INTERSTAGE DIFFERENTIAL ADJUSTMENT ON A T678A.

## CALIBRATION AND CHECKOUT

All controllers are carefully tested and calibrated at the factory under controlled conditions. If the controller is not operating at a temperature corresponding to the scale setting and differential setting, check to see that the sensing bulb senses the average temperature of the medium controlled. If the temperature of the controlled medium is changing rapidly, the differential will appear wider than its setting.

For calibration, an accurate temperature reading of the controlled medium must be taken. Place an accurate thermometer near the sensing bulb, or refer to a thermometer that has been installed as part of the system. If the sensing bulb is installed in an inaccessible area, or if the controlled medium is unstable, the bulb should be removed and placed in a controlled bath for accurate calibration.

### T675A

These controllers are calibrated so that the dial setting, indicated by the pointer on the adjustment knob, is the point at which the R-W switch contacts make on a temperature rise. Measure the temperature at the bulb. Rotate the adjustment knob counterclockwise from the top of the scale, simulating a temperature rise, until the R-W switch contacts make. Note the dial reading. If it differs from the bulb temperature, calibrate the dial as follows:

1. Determine the number of degrees difference between the bulb temperature and the dial reading at which the R-W switch contacts make.
2. Remove the adjustment knob and slip the fingers of the calibration wrench (accessory, Part No. 801534)

into the slots of the dial. Rotate the dial until the fingers of the wrench drop into the slots of the calibration nut under the dial. Note the dial indication at this point. Turn the dial and the calibration nut up or down scale the number of degrees that the bulb temperature differs from the point at which the contacts make (determined in step 1). For example, move the dial from 45 to 65 if the dial reading in step 1 was 45 degrees and the bulb temperature was 65 degrees.

3. Check the calibration adjustment by moving the adjustment knob up and down the scale while listening for the contacts to make and break. If the dial is still out of calibration, repeat the calibration procedure.

### T675B


**NOTE:** The cover must be removed to see the dial. All T675B models have been factory set and locked at 37 F [3 C].


These controllers are calibrated so that the dial setting, indicated by the fixed pointer at the top of the dial, is the point at which the switch contacts break on temperature fall.

Measure the temperature at the bulb. Remove the cover of the controller. Loosen the locking screw. Insert a screwdriver in the slot in the center of the dial. Start with the dial at the bottom of the scale, and rotate the dial counterclockwise to simulate a temperature fall until the switch contacts break. Note the dial reading. If it differs from the bulb temperature, follow the calibration procedure outlined for the T675A. Tighten the locking screw and replace the cover.

## T678A

These controllers are calibrated so that the dial setting, indicated by the pointer on the adjustment knob, is the point at which the R-W contacts of the right switch make on a temperature rise. If the temperature continues to rise, the R-W contacts of the left switch make at the dial setting *plus* the interstage differential. (The interstage differential is adjustable as shown in Figs. 10 and 11.)

Measure the temperature at the bulb. Rotate the adjustment knob counterclockwise  from the top of the scale, simulating a temperature rise, until the R-W contacts of the right switch make. Note the dial reading. If it differs from the bulb temperature, follow the calibration procedure outlined for the T675A.

After calibrating the dial, check the setting of the interstage differential. Set the adjustment knob at the bulb temperature. Then rotate the adjustment knob counterclockwise , simulating a temperature rise, until the R-W contacts of the left switch make. Note the dial reading. The difference between this reading and the bulb temperature is the interstage differential. The interstage differential may be adjusted if necessary (Fig. 11).

## CHECKOUT

Check the operation of the controller by raising and lowering the set point through the temperature range of the air or liquid being controlled. Make sure that the controlled equipment operates as intended.



APPENDIX C

OPERATION AND MAINTENANCE DATA

## PROTECTION FROM FREEZING AND OVERHEATING

At night and during the winter months the collector array will spend more time at ambient temperature than in a heated condition. Therefore, the collectors MUST be protected from freezing in areas where freezing occurs.

It also is true that during periods between the heating season and the cooling season much more heat is collected than can be used or stored, at least in normal sized storage systems. The excess heat MUST be disposed of without damaging the system or causing excess pressure.

Both problems can be solved by similar means, and the choice of the best protection system is the responsibility of the installer. The following methods are presented for consideration.

### FREEZE PROTECTION

#### Recirculation of Hot Water From Storage

In those areas where freezing is extremely infrequent, freezing of the distribution and collector array may be prevented by recirculating small amounts of water from storage to keep the water containing elements above the freezing temperature. This action, of course, is a waste of stored heat, and hence cannot be feasible in areas of frequent freezing.

A suggested control circuit is shown in Figure 19, in which contacts, C, operated by relay, R, control the operation of pump, P. "A" is a temperature control which responds to the temperature of the return line from the solar array at a point where it is exposed to outdoors. "A" closes its contact when the temperature as near as possible to the collector outlet falls to 35°F. Its bulb should be placed under the insulation, close to the collector. It closes relay, R, which starts the pump by means of contact, C, and also closes contact, R<sub>c</sub>, which holds the relay "in" after the temperature at A rises above 35°F.

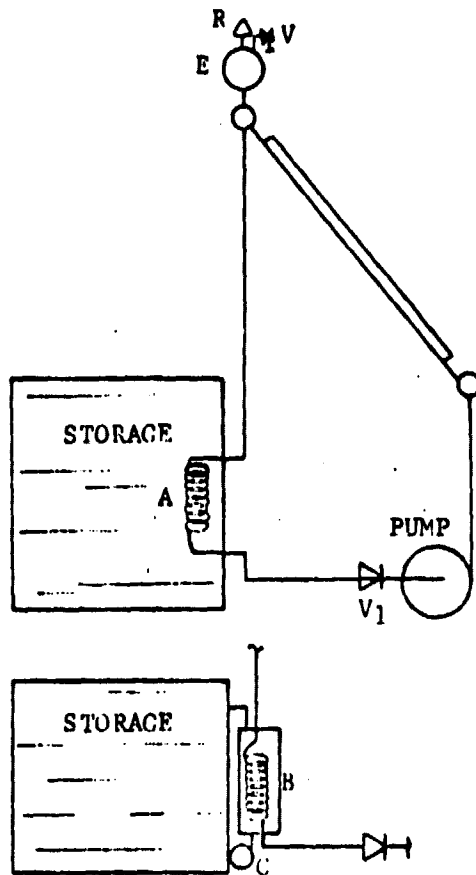


Figure 20

Typical Piping With Anti-Freeze  
in System

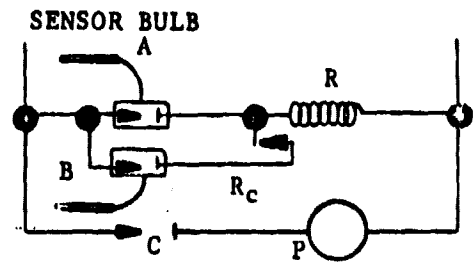


Figure 19

Control Circuit for Recirculation  
From Storage as Freeze Prevention

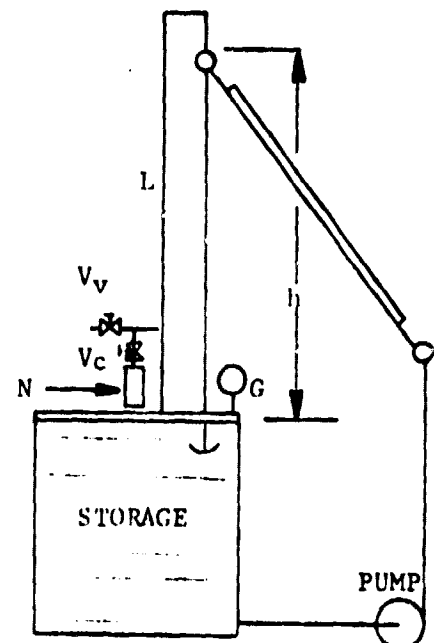


Figure 21

Drain-Down Freeze Prevention

### FREEZE PROTECTION (Continued)

Temperature controller, B, measures the temperature of the return line from the collector array at a point near where it enters the building, or the storage if it is located outdoors. It should be set to open its contacts on a rise in temperature to approximately 40°F.

With this system warm water is circulated long enough to assure that the entire distribution system has reached a non-freezing temperature each time the pump is started. CAUTION: DO NOT USE THIS SYSTEM OF FREEZE CONTROL IN AREAS WHERE FREQUENT OR PROLONGED FREEZING CAN OCCUR. IN AN EXTREME CASE, A SYSTEM COULD DISSIPATE THE STORED HEAT COMPLETELY AND FREEZE ANYWAY.

### Use of Anti-Freeze Solutions in the Collector Circuit

A preferred method of preventing freezing damage in areas where frequent sub-freezing weather occurs is the use of an anti-freeze solution in the collectors and associated piping. This necessitates a heat exchanger if the entire storage is not filled with the anti-freeze - usually too costly to consider due to the volume of the storage.

Figure 20 illustrates typical piping for use with anti-freeze. The closed circuit for the glycol or other anti-freeze requires the use of an expansion tank, E, to which may be attached the relief valve, R, and manual valve, V, for control of the air space in the tank.

The heat exchanger may be either inside the storage tank as at A, or outside as at B. A small additional pump, C, will usually be needed when an external heat exchanger is employed, and should operate whenever the collector pump runs.

To prevent thermal siphonal action causing circulation and consequent heat loss, a check valve should be used in the line to the collector pump suction, as shown at V<sub>1</sub>.

## FREEZE PROTECTION (Continued)

When using this approach to prevent freezing damage it should be noted that a somewhat higher collector temperature is needed to achieve a given temperature in the storage tank. The difference is usually 10° to 15°F even with a well designed heat exchanger, and must be taken into consideration in determining the number of collectors used. For a more detailed explanation of anti-freeze protected subsystems and related accessories see Appendix 1.

### Draining Collectors and Associated Piping

Freezing damage also may be prevented by draining the water out of the collector and all outdoor piping whenever insufficient heat is being received to hold a temperature above 32°F. A simple method of accomplishing this result is shown in Figure 21. The storage tank must be tightly sealed to prevent entrance of air or corrosion may result, and the collector array must be located completely above the storage tank.

All piping must be sloped for free draining back to the pump and the storage tank.

In addition to the circulating loop, a vent line, L, is run from the topmost location on the outlet header system of the collector array to the top of the storage tank. This line should terminate flush with the inside, to avoid submergence in the water surface. The vent line should be enclosed within the insulation of the outlet header so that it will be kept warm by the circulating fluid when the pump is operating.

For systems in which nitrogen charging is specified, Figure 21 illustrates provision for charging the void in the system with dry nitrogen. In closed loop systems the hydraulic industry normally considers this practice unnecessary. This is discussed as the first subject of Section VI - Corrosion Protection in the Fluid Circuit. Gas trapped in the system quickly is deoxidized and for all practical purposes is inert.

### FREEZE PROTECTION (Continued)

When a dry-nitrogen tank is connected to vent line, L, through charging valve  $V_C$ , a venting valve,  $V_V$ , also should be provided. Space must be left above the water in the storage tank to accommodate all the water from the collector array and external piping whenever the pump is not running. Under this condition the water should be at least 1 inch below the underside of the top of the storage tank. A pressure gauge, G, should be provided as on a hot water boiler to indicate a slight positive pressure at all times.

Using this system, the pump must be selected so that it is capable of providing the head, h, represented by the distance from the top of the water in the storage tank to the top of the return header at the collector array. Note that full flow need not be achieved at this head - only enough flow to provide a reasonably rapid filling of the system. A centrifugal pump should be used.

When the pump is not running, the highest water level in the external piping is the same as in the tank. Pumps normally are started when the temperature at the collectors rises above the temperature in the storage tank - usually well above 100°F. Upon starting, the pump draws from storage to fill the supply piping, the collectors, the outlet headers and return piping, forcing the inert gas or nitrogen back through the vent line, L, into the storage tank.

When the pump is stopped for any reason - say when the storage reaches its maximum desired temperature, or when no further solar energy is being collected - the inert gas or nitrogen flows back into the piping system and the collectors as the water drops back into the storage. Water flows back through the return header, and through the non-operating centrifugal pump.

## FREEZE PROTECTION (Continued)

The changes in water level between operating and non-operating periods are relatively minor in most systems, since the size of storage increases with the number of collectors. For a more detailed explanation of water drain-down subsystems and accessories see Appendix 1.

## PROTECTION FROM OVERHEATING

Whether a system provides space heating only, air conditioning only, hot water heating only, or any combination thereof, there are periods when more heat is collected than can be used or stored. It is important to provide for dissipation of this heat without boiling the water or anti-freeze in the collectors. The most commonly accepted methods to dissipate the heat are described below for the consideration of the systems installer of Chamberlain Solar Collector Panels. It is a responsibility of the systems installer to ascertain that adequate provision is made to protect the system and its components from excess heat.

### Dissipation to the Ambient

The excess heat may be dissipated from systems which cannot be drained, or are not intended to be drained, by an additional heat exchanger as shown in Figure 22. Thus this method applies to most systems using anti-freeze, although it can be used with the inhibited water systems.

Figure 22 shows a system similar to that shown in Figure 20-A. Valves A and B are added to bypass the heat exchanger whenever the maximum storage temperature is reached. Valves C and D divert the flow of anti-freeze to a finned coil type of heat exchanger, H, located outdoors. A fan is provided to circulate air through the heat exchanger when heat is to be dissipated.





### PROTECTION FROM OVERHEATING (Continued)

A temperature controller, T, measures the storage temperature at some location near the bottom. At low temperature valves A and C are open while B and D remain closed. Whenever the balance of the control system (not shown) senses that the collector temperature is above storage temperature the pump will operate and charge the storage.

When hot water in the storage near the bottom reaches the setting of controller, T, it closes valves A and C, and opens valves B and D to cause the heat exchanger to be bypassed, and the anti-freeze solution to flow through the outdoor heat exchanger, H. Controller, T, also should provide that when the balance of the control system starts the pump again, the fan of the outdoor heat exchanger, H, also operates.

As soon as the storage temperature falls below the setting of T the system reverts to normal operation to charge the storage again. This is a simple arrangement which dissipates excess heat at any time of year. It uses a minimum of controls in addition to the usual system controls.

It is the responsibility of the systems installer to provide a suitably sized heat exchanger to prevent boiling in the collector array under all conditions when this system is used.

### Draining Collectors and Associated Piping

The collector itself, if drained of fluid, will rise to a sufficiently high temperature to dissipate to the ambient any heat received. By adding a temperature control to Figure 21 for sensing the storage temperature near the bottom, and connecting it to prevent operation of the pump whenever the storage temperature becomes excessive, excess collection is prevented.

#### PROTECTION FROM OVERHEATING (Continued)

Use of this method of preventing overheating of the water and boiling in the collectors will result in high collector temperatures during stagnation periods of bright sunshine. Temperatures in excess of 400°F may be experienced, but the materials used in the Chamberlain Solar Collector Panels are chosen to withstand such temperatures. Suitable warnings or safety enclosures should be furnished if the collector array is located on the ground, and such safety measures are the responsibility of the systems installer.

## CORROSION PROTECTION IN THE FLUID CIRCUIT

The steel absorber plate used in this solar panel should be applied only in closed loop systems. That is a system which, once filled with the circulating heat transfer fluid, is closed and sealed from the atmosphere except for the periodic addition of make-up solution. These systems are operated pressurized from several psi to as high as 50 psi. A properly installed and chemically maintained system has long life expectancy.

In theory there should be no water caused problems in closed systems. The small amount of oxygen present in the water when the system is charged is dissipated quickly and a slight protective black film is formed on the internal surfaces, a condition observed in many hydronic systems after 20 or more years of operation. However, experience has shown that many systems do not behave in accordance with theory. Make-up water is required and the need for water treatment and periodic monitoring of fluid conditions in the system is now commonly accepted by the hydronic industry.

It is necessary to recognize precautions which must be taken to maximize the corrosion resistance of solar energy absorber panels. The following suggestions and discussion are offered to help the user to establish his own specific corrosion control program for the solar energy collection system.

It is anticipated that solar energy collector systems will be "multi-metal" systems in which the heat transfer fluid circulates through components of various base metals.

Internal corrosion problems in solar absorber panels relate primarily to the nature and corrosive characteristics of the heat transfer fluid used. In turn, the choice of heat transfer fluid relates to system design and to the type of service for which the system is intended. The two basic systems are:

1. Systems in which the heat transfer fluid can be exposed to temperatures below 32°F (0°C).
2. Applications in which the fluid is not exposed to freezing temperatures.

### TRANSFER FLUID EXPOSED TO FREEZING

In the first type of application -- where the heat transfer fluid is exposed to low temperatures -- heat transfer fluids chosen may be water-ethylene glycol antifreeze mixtures or suitable nonaqueous heat transfer fluids which remain fluid at low ambient temperatures.

#### Glycol-Water

Corrosion problems may develop either because of water chemistry (impurities in the water) or by degradation of the ethylene glycol. Ethylene glycol breaks down gradually in use. The end products of glycol degradation include organic acids which progressively and substantially lower the pH of water-glycol mixtures to levels at which the resulting acid solution will become seriously corrosive to steel. Commercial antifreeze formulations contain various "buffers" and "inhibitors." The "buffers" are intended to control the pH level. However, their effect is limited and if glycol degradation is allowed to continue indefinitely, the "buffers" will be used up and the solution will become acid. For example, in automotive service we have the usual recommendation that the water and antifreeze mixture be drained and replaced at safe intervals, usually one or two years.

In hydronic glycol systems corrosion inhibitors are required and must be monitored. If concentration of the inhibitor drops below a protective level, the inhibitor level must be re-established.

### TRANSFER FLUID EXPOSED TO FREEZING (Continued)

It is important to note that one of the major factors determining the rate at which ethylene glycol degrades is the temperature to which it is exposed. The higher the temperature, the more rapid the degradation. Although "normal" maximum operating temperatures for most solar collector systems are below maximum automobile radiator temperatures, solar collectors will reach higher temperatures under stagnation conditions. When the heat exchanger fluid is not circulating through the absorber, temperature will rise. Typical summertime stagnation temperatures will be above 375°F. At such temperatures, glycol degradation will be accelerated substantially. It follows that the condition of the glycol-water solution in solar service must be monitored and that the water-glycol mixture must be replaced when degradation has progressed to the point that the solution will become acid. System maintenance is critical. It is known that operating conditions, including temperature profiles of solar systems, are quite variable from system to system. Therefore, it is not possible to prescribe specific intervals for change of the heat transfer fluid. From this it is apparent that system monitoring is critical.

Scaling can cause serious problems in hydronic systems if precautions are not taken to control soluble salts in the water. When water with high hardness is used in the system even a small amount of make-up, over a period of time, will cause difficulty. Difficulty also can be experienced with low hardness water if high make-up volume is required.

### Galvanic Corrosion

Galvanic corrosion problems occur because of the presence of dissimilar metals in a multi-metal system. Less "noble" metals will corrode preferentially in contact with more "noble" metals. For example: Copper will

### TRANSFER FLUID EXPOSED TO FREEZING (Continued)

galvanically corrode aluminum or steel, steel will galvanically corrode aluminum, etc. One source of galvanic corrosion is direct electrical connection between two dissimilar metals.

Another source of galvanic corrosion is the presence of ions of the more "noble" metals in solution which galvanically deposit on the surface of the less "noble" metal. The "inhibitors" in hydronic systems and water/antifreeze formulations are designed to minimize this problem by suppressing corrosion of all metals in the system and thereby reducing the extent to which metal ions go into solution.

### Erosion Corrosion

Heat transfer fluid design velocity through the system should be limited to four to six feet per second to prevent erosion-corrosion of the system.

### Non-Aqueous Systems

An alternate to water-glycol antifreeze mixtures is the application of non-aqueous solutions. There are a number of fluids which the manufacturer identifies as being chemically stable at 400°F and over. Other characteristics claimed are non-corrosive and non-ionic, therefore not capable of supporting galvanic corrosion.

"Dowtherm J" is a preferred non-aqueous solution. It has been used as a heat transfer fluid at temperatures above 450°F. The manufacturer's literature states that it is "non-corrosive" toward common construction metals such as steel, copper, aluminum and stainless steel alloys. If you are interested in Dowtherm J, contact the Functional Products and Systems Department of the Dow Chemical Company in Midland, Michigan 48640, for additional advice and information concerning Dowtherm J, particularly that relating to the proper procedures to be followed in its use.

### TRANSFER FLUID EXPOSED TO FREEZING (Continued)

It should be noted that, characteristically, non-aqueous heat transfer fluids (such as Dowtherm J) have lower thermal capacity and inferior heat transfer characteristics as compared to water-glycol mixtures. This means that, for equal heat transfer efficiency the wetted area of heat transfer surface and the total cross-section of the heat transfer passages in a solar absorber panel will have to be greater when such fluids are used than when water-glycol mixtures are used.

Wetted area of our absorber plate is high enough that loss of transfer efficiency in this area is of no importance. However, the heat exchanger required for transfer of heat to storage necessarily will have to be considerably larger.

Viscosity of non-aqueous fluids usually are substantially higher (particularly at low temperatures), a factor which must be taken into consideration in system design.

### TRANSFER FLUID NOT EXPOSED TO FREEZING

The commonly used fluid is water. In many cases, it is desirable to use potable water as the fluid. An example is a solar water heater in which the use of potable water as the heat transfer fluid will allow combining the collector circuit with water storage. As indicated previously, potable waters are highly variable in their composition and corrosivity. Most, but not all, can be used in copper without corrosion problems. Steel absorber plates are not suitable for potable water application.

### INHIBITORS

In the case of steel with water or water glycol solutions, it is necessary to treat the water in order to insure the integrity of the protective films.

### INHIBITORS (Continued)

Various types of inhibitor blends are commercially available and instructions for their use can be obtained from water treatment companies.

Nitrite base corrosion inhibitor systems are best suited for this type of service. They are compatible with the water-ethylene glycol mixtures most often used in solar energy collection systems. Further, nitrite based inhibitors usually are acceptable to health authorities whereas chromate based inhibitors are not.

Some of the water treatment companies who have nitrite-borax and organic inhibitor blends available are listed below.

<u>Company</u>	<u>Product</u>
Betz Laboratories, Inc. Somerton Road Trevose, PA 19047	Corr-Shield K-7
Calgon Corporation Water Management Division Box 1346 Pittsburgh, PA 15230	Corrosion Inhibitor "CS"
Dearborn Chemical Division Chemed Corporation 300 Genesee Street Lake Zurich, IL 60047	Dearborn 537
Drew Chemical Company Division U. S. Filter Company 1000 East 80th Place Merrillville, IN 46410	CWT 110
Nalco Chemical Company 2901 Butterfield Road Oak Brook, IL 60521	Nalco 39

Treatment of closed systems with these inhibitors will not be expensive. Some companies have test kits available for monitoring the system. In all cases a regular schedule should be established to check for inhibitor



### TRANSFER FLUID NOT EXPOSED TO FREEZING (Continued)

concentration as well as the possibility of the glycol producing an acidic condition caused by degradation from high stagnation temperatures. Such monitoring is important regardless of which material is used for the absorber.

**CAUTION: CHROMATE INHIBITORS SHOULD NOT BE CONSIDERED FOR USE WITH WATER-ANTIFREEZE MIXTURES.**

As indicated above, all of these suggestions offered for the consideration of the system designer or user are intended to help optimize corrosion protection of system components. Recognize there is substantial diversity of system design and this may introduce other factors which ultimately control the rate of corrosion. The design of collector hydronic and storage sub-systems is beyond our control.

In view of the circumstances outlined above, what has been offered in the foregoing discussion are suggestions intended to assist the designer and user in optimizing the performance of the final product. They should not be considered as constituting an implied warranty and are advisory in nature. The only warranty which we can reasonably provide is included as part of Section 1 of these instructions.

### SYSTEM CLEANING, CHARGING AND INHIBITOR MONITORING

Startup of a solar system must be accomplished under strictly controlled conditions. Under no circumstances shall a system be charged, with water or heat transfer fluid, prior to cleaning. A typical procedure and cleaning materials specification is outlined on the following page. Charge the system immediately after completing the cleaning and flushing operation, including the inhibitors.

## SYSTEM CLEANING, CHARGING AND INHIBITOR MONITORING (Continued)

DO NOT ALLOW THE SYSTEM TO STAND IDLE FOR ANY PERIOD OF TIME WITH INTERNAL SURFACES STRIPPED OF ALL PROTECTION.

### Cleaning the Solar Hydronic System

The hydronic system shall be cleaned typically in accordance with the following:

1. Before connecting the solar panels into the system, add jumper piping and panels at the solar array and thoroughly flush out the system with water so as to remove any foreign matter that can be removed by flushing.
2. Drain the entire system including piping and equipment. Also clean strainers. At this time connect the solar panels into the system.
3. Fill system with specified chemical formulated cleaning materials to proportions of 60 pounds per 1,000 gallons cleanwater. (See Cleaner Composition specifications, Page VI-9).
4. Heat solution and maintain temperature at 150°F to 170°F. Circulate solution for a minimum period of 24 hours.
5. Use permanent system pumps and heat exchangers to accomplish the heating of solution, temperature maintenance and circulation. If heat is not available, the cleaning strength should be doubled or the normal strength should be circulated for a minimum of 48 hours.
6. Temporary side stream filter around pumps to remove foreign materials may be used. Size of filter shall be sufficient to by-pass the equivalent system volume in four hours. Filter medium shall be 25 microns in size.
7. If filters are used, replace filter medium as necessary to assure proper flow rate through filter during the entire 24 hours.

## SYSTEM CLEANING, CHARGING AND INHIBITOR MONITORING (Continued)

8. Drain and flush system with new water to remove all alkalinity from cleaning. Clean strainer and clean out legs.
9. After satisfactory completion of cleaning and flushing operations, all water used for cleaning and testing of the system shall be drained completely. The entire system shall then be filled with treated water. Level of treatment shall be reached as soon as possible.

### Cleaner Composition

Following is a typical composition by weight for a hydronic cleaning compound. This formulation is satisfactory for steel, copper, brass or copper alloys, but is not satisfactory for aluminum or galvanized pipe.

	<u>% By Weight</u>
Soda Ash	10.0
Caustic Soda	45.0
Trisodium Phosphate Anhydrous	8.0
Sodium Meta Silicate	7.0
Sodium Gluconate	15.0
Wetting Agents and Surfactants	10.0
Sodium Chloride	<u>5.0</u>
	100.0%

Note: At 60 pounds cleaner per 1,000 gallon level, total alkalinity is approximately 6,000 ppm. After cleaning and flushing, alkalinity should be within 50 ppm of fresh rinse water. Continue to flush after cleaning until this value is reached. The conductivity meter listed under Suggested Instrumentation (Reference Page VI-16) can be used to check level of cleaning solution in the system.

## SYSTEM CLEANING, CHARGING AND INHIBITOR MONITORING (Continued)

### Corrosion Inhibitor Specification

The specified material is a borax-nitrite mixture containing special organic and inorganic inhibitors.

- |                                     |  |
|-------------------------------------|--|
| I. <u>Physical Form:</u>            | Shall be an off-white colored, free flowing, granular product with a bulk density of 71-77 lbs/ft <sup>3</sup> .   |
| II. <u>Composition:</u>             | Shall be a mixture of borax, sodium nitrite, benzotriazole and inorganic corrosion inhibitors. Minimum NaNO <sub>2</sub> content is 70%. Minimum triazole content 1.8%.  |
| III. <u>Water Insoluble Matter:</u> | Less than 0.1% by weight.  |
| IV. <u>pH Value:</u>                | The pH of a 1% aqueous solution at 25°C shall be 7.0-8.5.  |
| V. <u>Performance Assurance:</u>    | <p>The product shall meet the following performance requirements:</p> <ul style="list-style-type: none"><li>(a) Be compatible with ethylene glycol and methanol types of antifreezes.</li><li>(b) Impart no color to the treated water.</li><li>(c) Not be detrimental to painted surfaces, pump glands and packings, or water seals.</li><li>(d) Not cause dermatitis when handled by operators with reasonable care.</li><li>(e) Contain a specific inorganic corrosion inhibitor effective in reducing corrosion of aluminum.</li></ul> |
| VI. <u>Containers:</u>              | Shall be delivered in non-returnable moisture-proof, fiber drums.  |

NOTE: Calgon Corporation's Corrosion Inhibitor CS will meet these specifications.

## SYSTEM CLEANING, CHARGING AND INHIBITOR MONITORING (Continued)

### Recommended System Chemistry Control

The range of inhibitor concentration in a typical system as sodium nitrite would be from a minimum of 1,400 ppm to a maximum of 4,000 ppm. The normal recommended operating concentration would be 2,000 ppm as sodium nitrite.

As noted in the Corrosion Inhibitor Specification the pH of a 1% aqueous solution of the inhibitor at 25°C shall be 7.0 to 8.5. The system normally should operate slightly on the alkaline side.

At the time of system charging a conductivity level will be established as the result of adding the prescribed inhibitor concentration to new water. This conductivity level should be recorded as your system base line.

### Charging the System

When filling the system chemicals can be injected by means of a by-pass pot-type feeder of proper size installed in the closed loop. See Figure VI-1. Having a pot-type feeder in the system allows the operator an easy method of adding chemicals whenever necessary. Chemical addition requirements are dictated by the in-plant tests performed by the operator on a routine basis.

It can be stated that very serious corrosion and scale problems in the closed system are directly proportional to the make-up water added to the system. Therefore, every effort should be made to maintain a closed system.

The amount of make-up can be determined in a closed system by several techniques used in chemical tracing. In the case of nitrite, a simple series of time versus concentration tests will provide a method of determining the amount of make-up actually going into the system.

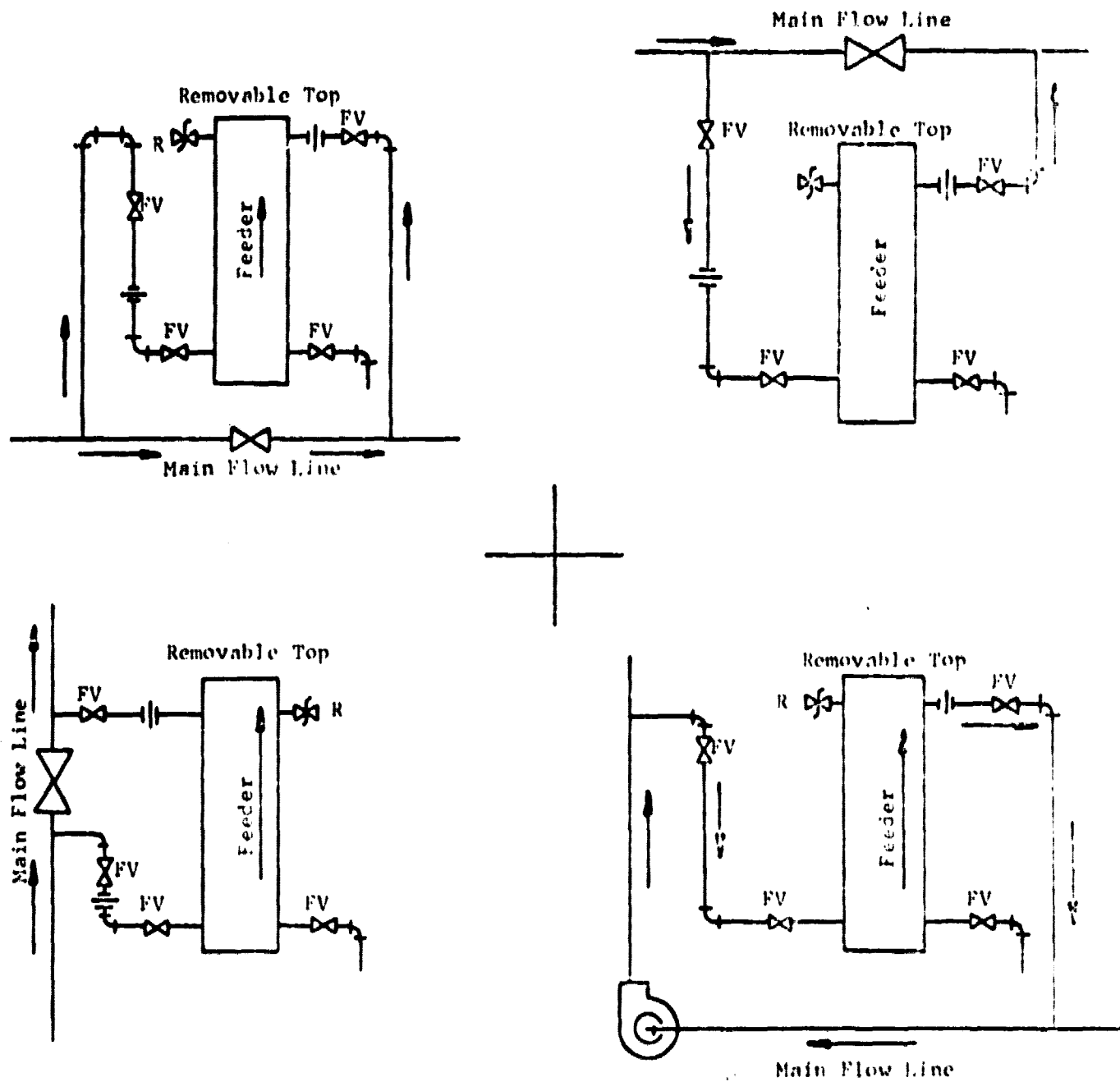


Figure VI-1. Typical Arrangements for Pot or By-Pass Type Feeder

## SYSTEM CLEANING, CHARGING AND INHIBITOR MONITORING (Continued)

Instrumentation for monitoring nitrite is readily available. Inhibitor suppliers usually have kits available.

Calgon Corporation has such a kit, their Catalogue No. K0065.

### Closed System Charging and Volume Calculation

In Chemical Charging and Controlling of Chemical levels in a system, it is desirable to know actual volume of the system. This can be accomplished in several ways. The most direct is to install a meter in the fill line.

Calculation of the volume is sometimes attempted, however, accuracy of calculated volume at best is an approximation. A more acceptable procedure would be to track chemical concentration. In applying this procedure estimate and purposely put in an initial chemical "charge" lower than estimated need, then test. A second addition of chemical is then made and tested. From the weight of chemicals and test results one can calculate the actual volume of the system. Once the exact volume is known, it is possible to add an exact amount of chemical to bring the readings to proper limits without guess work.

The procedure is demonstrated by the following illustrative example:

Let us assume our cost studies clearly show product "A", a powdered material, is most economical and does the job. That product "A" must be added at a level of one pound per 50 gallons to give minimum protection. Further, that this recommended addition by the supplier is equivalent to our instrument nitrite reading of 1,400 ppm nitrite. We therefore not only can charge the system but can figure the actual volume of the system by using the following technique:

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OF FOUR QUALITY

## SYSTEM CLEANING, CHARGING AND INHIBITOR MONITORING (Continued)

### Step One:

First estimate gallons in the system from physical layout and/or drawings. For large systems add one pound of "A" per 50 gallons. Anything under 100 gallons use 1.5 pounds "A" per 50 gallons.

Instrument nitrite reading for one pound "A" per 50 gallons = 1,400 ppm NO<sub>3</sub>.

After adding charge of X pounds of product "A" you get 800 ppm nitrite reading.

NOTE: 0.1 pound "A"/50 gallons = 140 ppm nitrite increase

1 pound "A"/500 gallons = 140 ppm nitrite increase

### Step Two:

After the second addition of say Y pounds of "A", we get a 390 ppm increase, that is to say 800 ppm + 390 ppm = 1,190 ppm nitrite reading on the second sample.

### Step Three:

We can now calculate actual volume in the system as follows:

$$\frac{390 \text{ ppm}}{140 \text{ ppm}} = 2.79 \text{ -- but 1 pound of "A" equals a 140 ppm increase in 500 gallons.}$$

Therefore actual volume of system is equal to Y pounds of "A" added for the 390 ppm increase ratio

$$Y \text{ Pounds} \times \frac{500}{2.79} = \text{Total Gallons in System.}$$



## SYSTEM CLEANING, CHARGING AND INHIBITOR MONITORING (Continued)

### Step Four:

For the third adjustment go to 2,200 ppm. This gives a 200 ppm reserve inhibitor since 2,000 ppm is the normal level.

$$2,200 \text{ ppm} - 1,190 \text{ ppm} = 1,010 \text{ ppm increase needed in system.}$$

Therefore:

$$\frac{1,010 \text{ ppm}}{140 \text{ ppm}} = 7.21 \text{ pounds "A" needed for each 500 gallons in the system.}$$

Pounds of "A" to add to the system is obtained as follows:

$$\begin{array}{l} \text{Total Gallons of} \\ \text{System From Above} \end{array} \times \frac{7.21 \text{ Pounds "A"}}{500 \text{ Gallons}} = \begin{array}{l} \text{Pounds "A" required to} \\ \text{reach 2,200 ppm level} \\ \text{in the system.} \end{array}$$

The reason for adding 1.5 pounds of "A" for small systems is that as long as the reading for nitrite is over the minimum of 1,400 ppm you are safe. At 1.5 pounds of "A" per 50 gallons we obtain a level of 2,000 ppm nitrite. Larger levels of nitrite are not harmful. However, in large systems of 5,000 to 10,000 gallons the above method optimizes the treatment, allowing us to determine the volume. Once the above is done accurately we will know how much chemical will be necessary to bring such a system up to any level, when for any reason we lose part of the system's water or have a drop in nitrite reading. We can calculate the exact amount of chemical "A" necessary to bring the system's nitrite content from a low reading to the desired level. A fixed weight of "A" will raise a fixed volume of the system by an exact amount.

## SYSTEM CLEANING, CHARGING AND INHIBITOR MONITORING (Continued)

### Monitoring the System

The following specific items must be monitored for your system:

1. Nitrite concentration.
2. Total Dissolved Solids (TDS) (conductivity).

See the Suggested Instrumentation section below for details on instrument identification and availability.

Since exposure to change is greatest during the first few weeks of operation, it is important that each of these items be monitored daily for the first week, weekly for eight (8) weeks or until readings stabilize, and then monthly.

Attached is a suggested log sheet.

### Suggested Instrumentation

1. Nitrite Analyzer - Catalogue #K-0065 and reagents R5237 and R5018

Water Chemicals Department  
Calgon Corporation  
Calgon Center  
Pittsburgh, PA. 15230

2. Conductivity Meter - Catalogue #SD-23641-F Solu Bridge

Beckman Instruments, Inc.  
Cedar Grove, NJ

# ALL CLOSED SYSTEMS WATER TREATMENT LOG SHEET

Plant Location \_\_\_\_\_ Period Covered \_\_\_\_\_ to \_\_\_\_\_

System Code \_\_\_\_\_ Analyses \_\_\_\_\_ lbs. Chemical Added \_\_\_\_\_

Date												Date	Nitrite Inhibitor
Nitrite													
Conduct.													

System Code \_\_\_\_\_ Analyses \_\_\_\_\_ lbs. Chemical Added \_\_\_\_\_

Date												Date	Nitrite Inhibitor
Nitrite													
Conduct.													

System Code \_\_\_\_\_ Analyses \_\_\_\_\_ lbs. Chemical Added \_\_\_\_\_

Date												Date	Nitrite Inhibitor
Nitrite													
Conduct.													

System Code \_\_\_\_\_ , Total Gallons \_\_\_\_\_ , Description or Remarks \_\_\_\_\_

System Code \_\_\_\_\_ , Total Gallons \_\_\_\_\_ , Description or Remarks \_\_\_\_\_

System Code \_\_\_\_\_ , Total Gallons \_\_\_\_\_ , Description or Remarks \_\_\_\_\_

ORIGINAL PAGE 2  
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## STARTUP, OPERATION AND MAINTENANCE

### START-UP AND OPERATION

After all piping has been completed and the storage system has been filled, the piping and collector connections should be tested for leaks. The piping portion can be tested at pressures up to 50 psig. Pressure testing will require valving off from the storage tank unless it is designed to take the same pressure. The glycol systems of Figures 20 and 22 must be tested separately. Add any needed inhibitors and bring to desired pH.

Check the system to see that the pump operates and circulates the required amount of fluid. If the self-draining system of Figure 21 has been used be sure that all the fluid drains back into the storage after the pump is stopped.

ONLY AFTER COMPLETING THE FOREGOING STEPS SHOULD THE PLASTIC BANDS AND THE COVER MATERIALS OVER THE GLASS BE REMOVED. After their removal the system should begin to collect heat whenever it is available from the sun.

Observe that the expansion tank of systems shown by Figures 20 and 22 are approximately half full of air - pump more air in if needed after the system warms up and valve a small amount of the anti-freeze solution out, keeping it in a closed container until needed again.

For the system of Figure 21, when dry nitrogen purging is used, it is best to eliminate all the air possible by opening the vent valve,  $V_v$ , and overfilling the storage until some water vents. Then close the vent valve, and start draining some water from the storage, while opening the nitrogen charging valve,  $V_c$ . Watch the pressure gauge to see that the limiting pressure is not exceeded. When the water in the storage is well below the top of the tank, close the nitrogen charging valve. If the water level comes less than an inch from the top of the storage as the system heats, valve out more water. Repeat until some nitrogen is still trapped in the storage below the top.

### STARTUP AND OPERATION (Continued)

It is normal for some gases to be released from the water as it heats. This will gradually increase the pressure over a few hours or a few days. As this happens, open the vent valve while the pump is not in operation and bleed down to atmospheric pressure, to thus remove as much as possible of the oxygen rich mixture. Then close the vent and the nitrogen valve to restore the proper pressure. This process should be repeated four or five times. Thereafter, merely hold the proper pressure by bleeding in nitrogen. In a tight system this seldom should be necessary.

### MAINTENANCE

Chamberlain Solar Collector Panels are designed to need little maintenance. Yet provision is made for certain operations in the field without removing the panel from the rack.

#### Glass Breakage

The use of tempered glass should prevent all but the most unusual breakage. Should a glass cover break the outer cover frame can be removed and the glass replaced. Follow this procedure:

1. Remove the hold-down screws which attach the cover assembly to the collector housing. Then remove the glass in the frame to a convenient location.
2. Remove the retainer screws in the corner locking pins, allowing either the two ends or two sides to be removed.
3. Insert spacers at the edges of the glass to retain the glass separation distance when the frame is dismantled.

### MAINTENANCE (Continued)

4. Carefully remove the rubber (EPDM) seal from the aluminum extrusion or the edge of the glass.
5. Position a new piece of glass on the spacers for separation after ascertaining that it is in clean condition.
6. The EPDM seal then is placed around the edge of the glass, and the aluminum frame is replaced.
7. The corner locking pins then are replaced, and the assembly is mounted on the collector housing and is attached with the original sheet metal screws.

The single glass cover procedure is similar, except that the spacers are not needed.

### Filter

Need to clean the fluid filter will be evident if the temperature difference between the pump outlet and the return to the storage system increases beyond normal. Keep the filter clean - doing so helps collect a greater amount of solar energy.

### Inhibitor and pH Control

Within 30 days after the system is first started the amount of inhibitor remaining active in the water or anti-freeze solution should be determined. Use the advice of the corrosion consultants to see whether any changes in amounts or type of treatment are needed. Thereafter follow their recommendations in maintaining the inhibitor and pH levels.

### General

In working over the collectors one must be prepared for exposure to considerable heat. Special ladders can be arranged to span the collector

### MAINTENANCE (Continued)

array even if it is two or three rows high. It should have a shield to allow the workman reasonable comfort while he works.

Care must be exercised to avoid dropping tools on glass covers. THEY CAN BE BROKEN. One good method is to use plywood sheets with a wooden "hook" to rest over the top of collectors adjacent to the work. This protects both the collector and the workman.

### SPARE PARTS

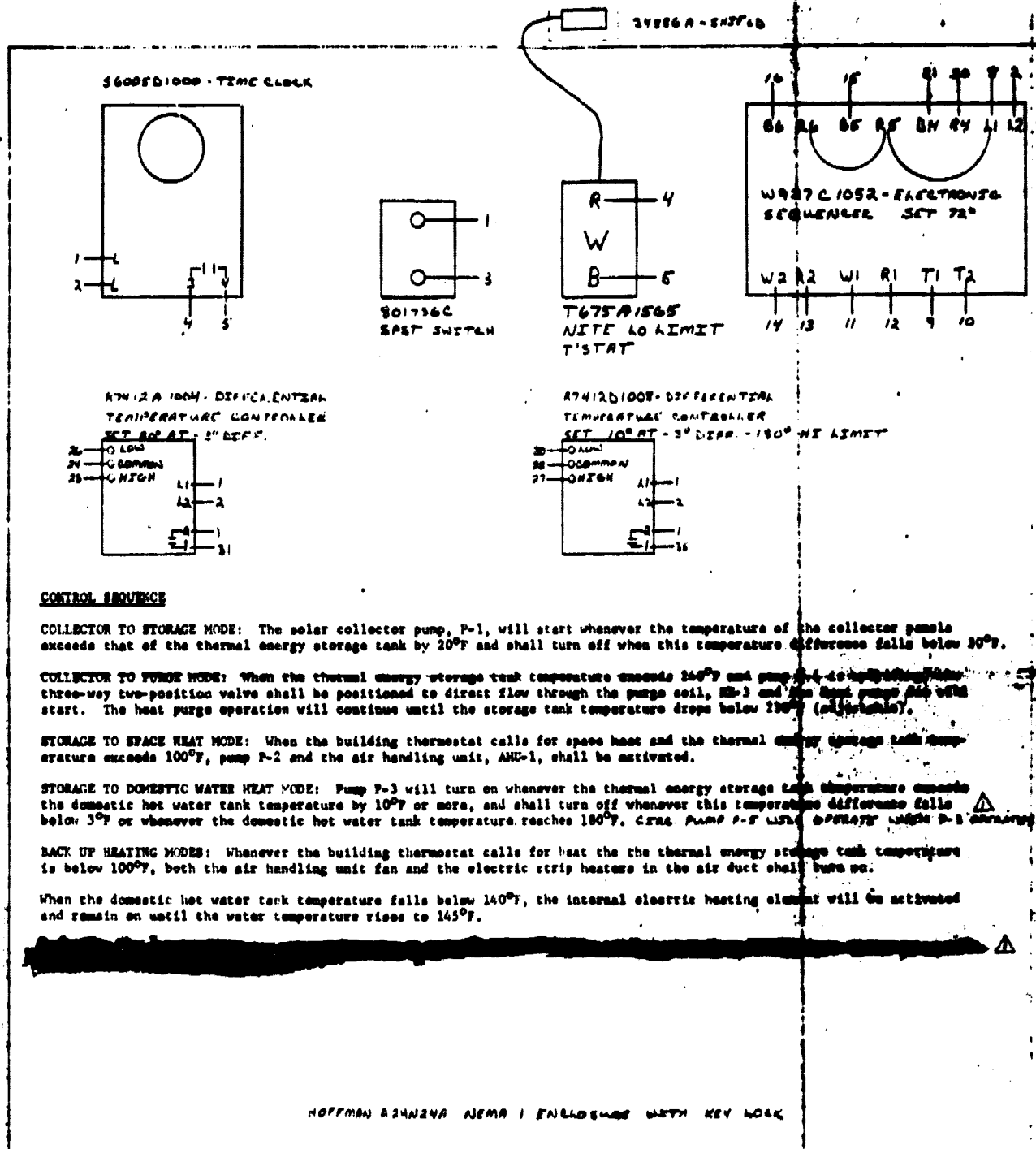
For very large installations it is wise to stock several extra frames with glass installed to expedite replacement of any broken glass. The time saved may well be worth the investment.

A parts list can be obtained by writing to Chamberlain Manufacturing Corporation.

**APPENDIX D**

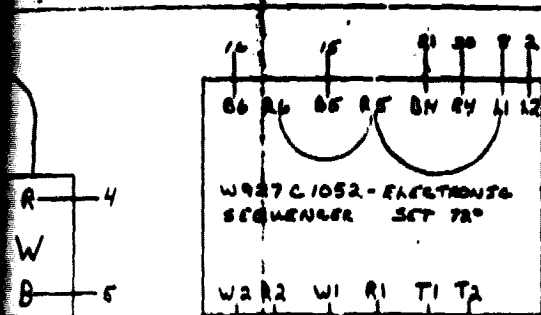
**PROJECT DRAWINGS**





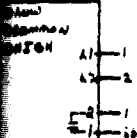
FOLDOUT FRAME

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OF POOR QUALITY



675A1565  
ITE LO LIMIT  
STAT

741201008-DIFFERENTIAL  
TEMPERATURE CONTROLLER  
AT 10° AT - 3° DIFF. - 180° HI LIMIT



It whenever the temperature of the collector pencils  
turn off when this temperature difference falls below  $30^{\circ}\text{F}$ .

temperature exceeds 240°F and goes 3-4 in. below the surface through the purge exit, SH-3 and the heat pumps are used to maintain temperature drops below 240°F (adjustable).

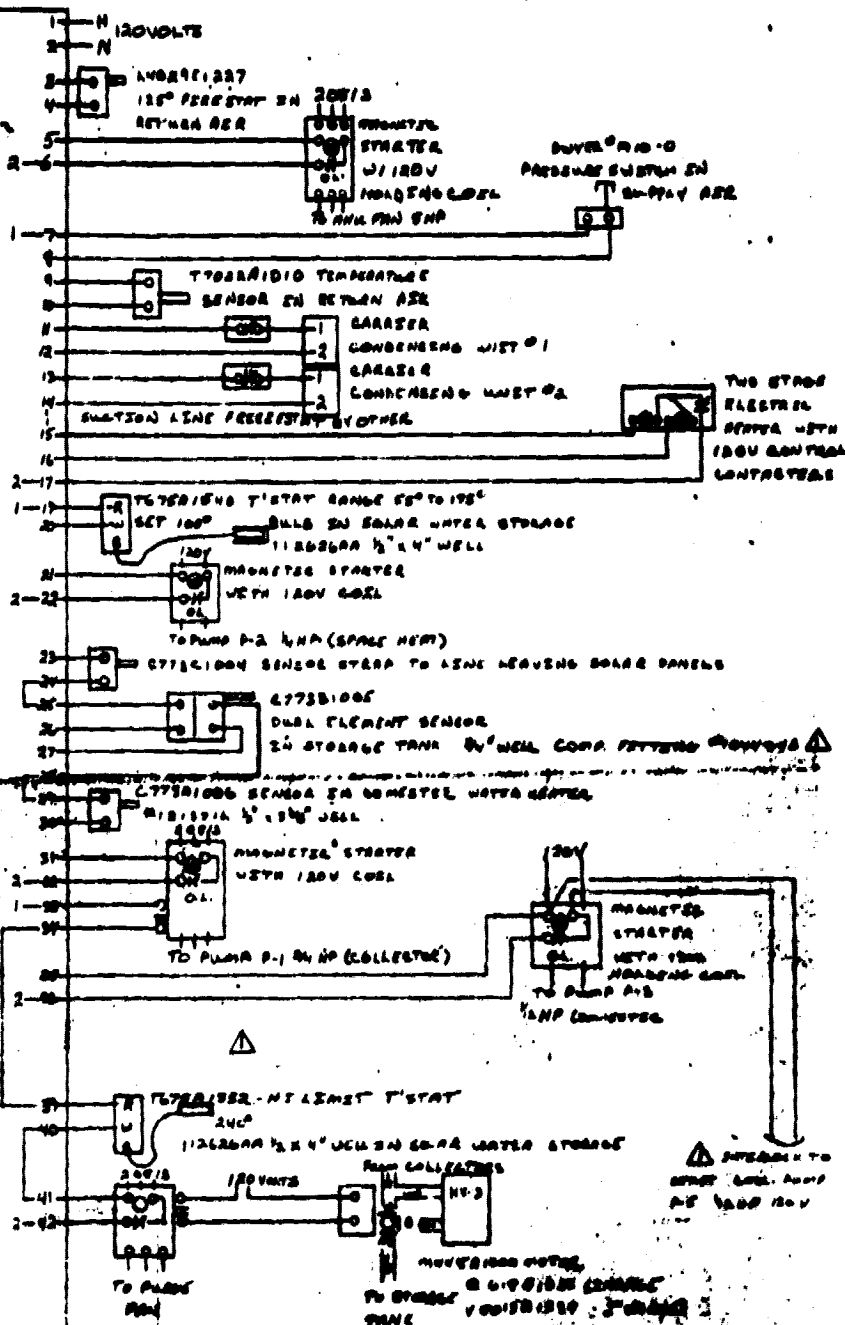
space heat and the thermal energy storage tank will be activated.

the thermal energy storage tank temperature exceeds 180°F, the pump will turn off whenever this temperature difference falls below 100°F. CIRC PUMP P-5 WILL OPERATE WITH P-3 OR P-4.

Heat the the thermal energy storage tank temperature  
the heaters in the air duct shall vary as:

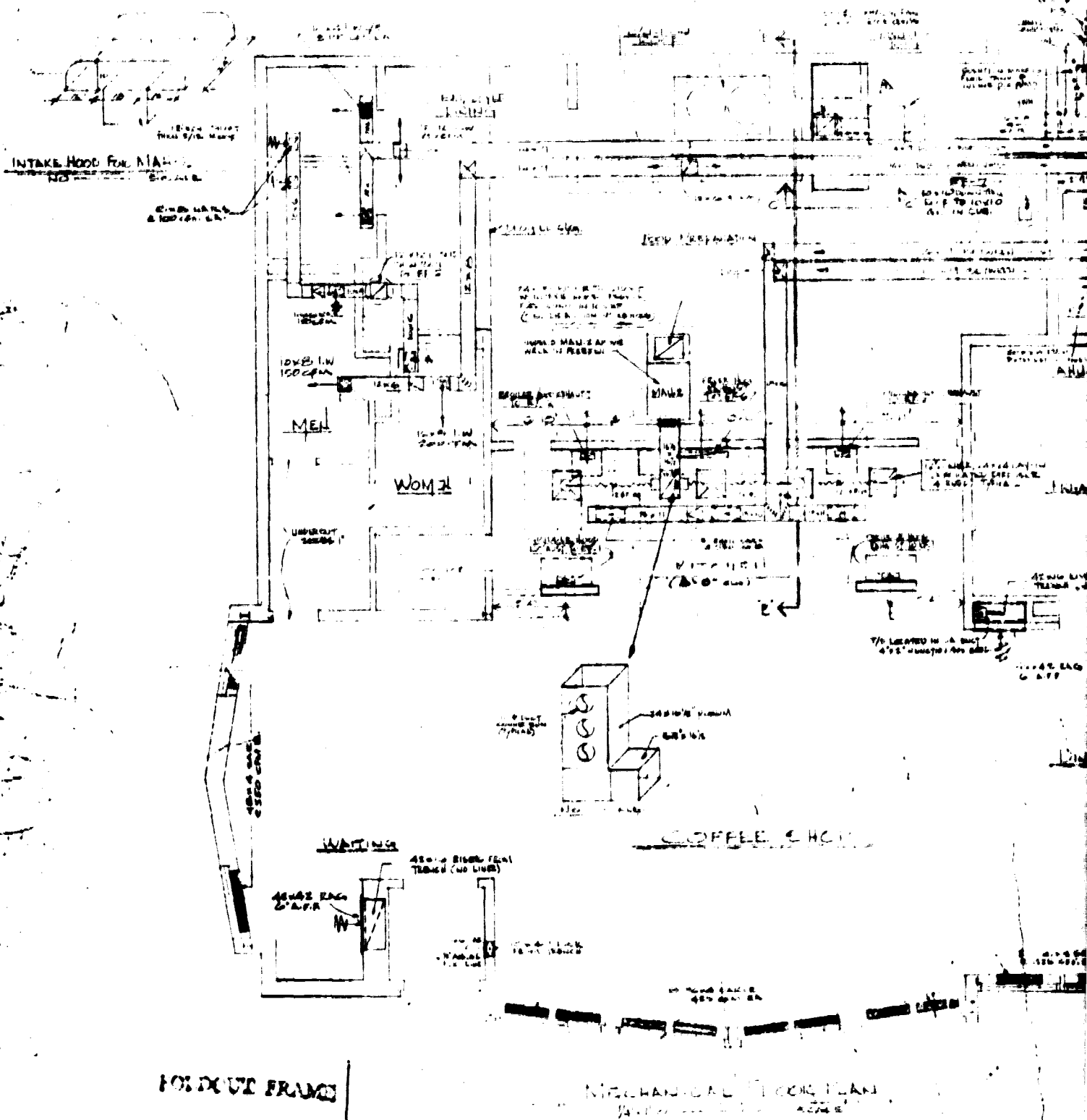
internal electric heating element will be activated

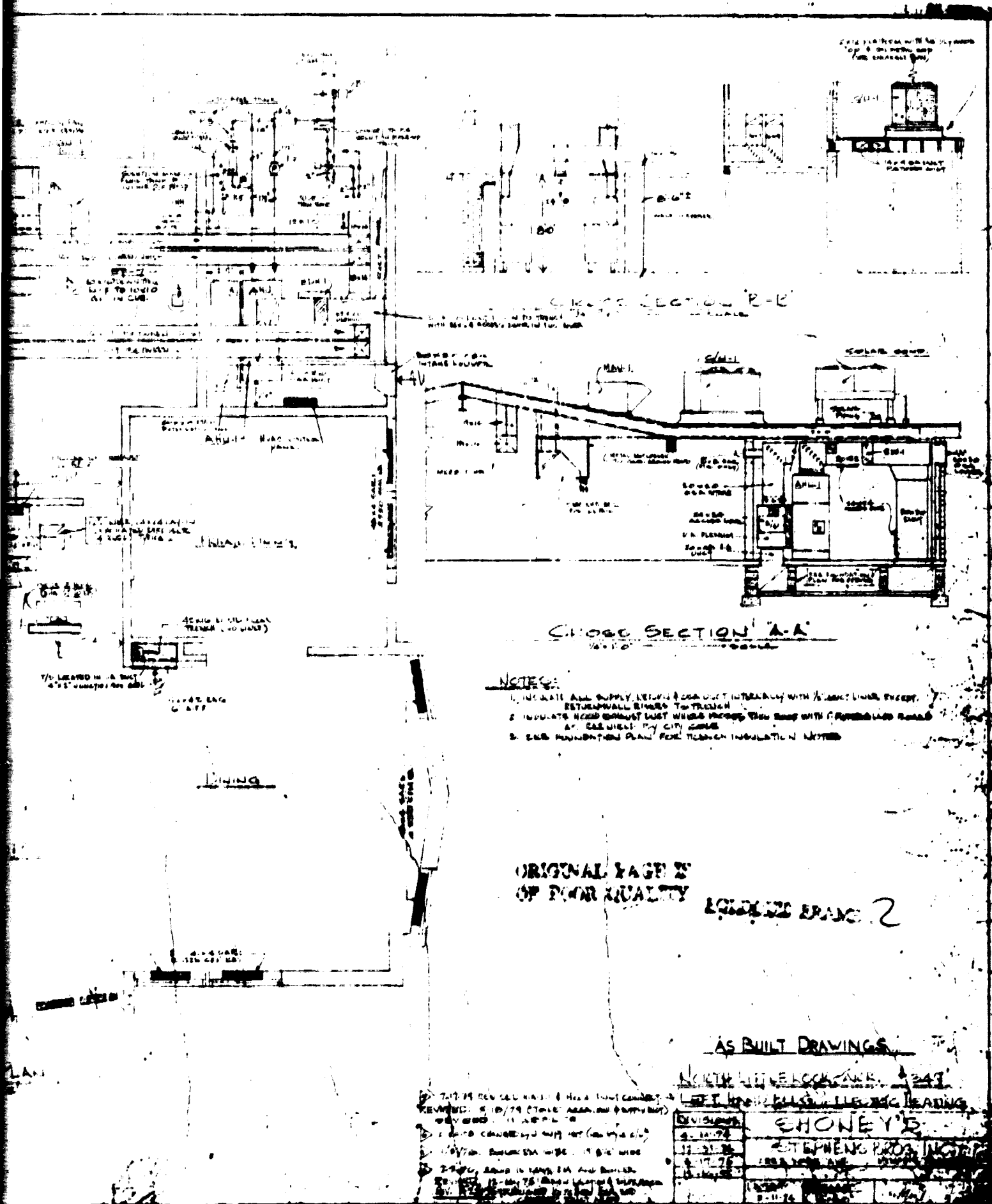
### BLOKING WITH KEY LOCK



FOLDOUT FRAME 2

TEMPERATURE CONTROL SYSTEM		
SHONEYS		
LITTLE ROCK ARK.		
INDUSTRIAL MECHANICAL SUPPLIES		
PA 7-264	FEB 9, 1961	4407





**NOTES:**

1. INDICATE ALL SUPPLY, RETURN & EXHAUST INTERFACES WITH EXISTING LINES EXCEPT RETURN WALLS BUILT TO TROUGH
2. INDICATE NEED EXHAUST DUCT WHERE PRESSURE FROM ROOF WITH FIREHOLE ROADS AT EXISTING CITY CODES
3. SEE FOUNDATION PLAN FOR TRENCH INSULATION NOTES

ORIGINAL PAGE 2  
OF FOUR QUALITY

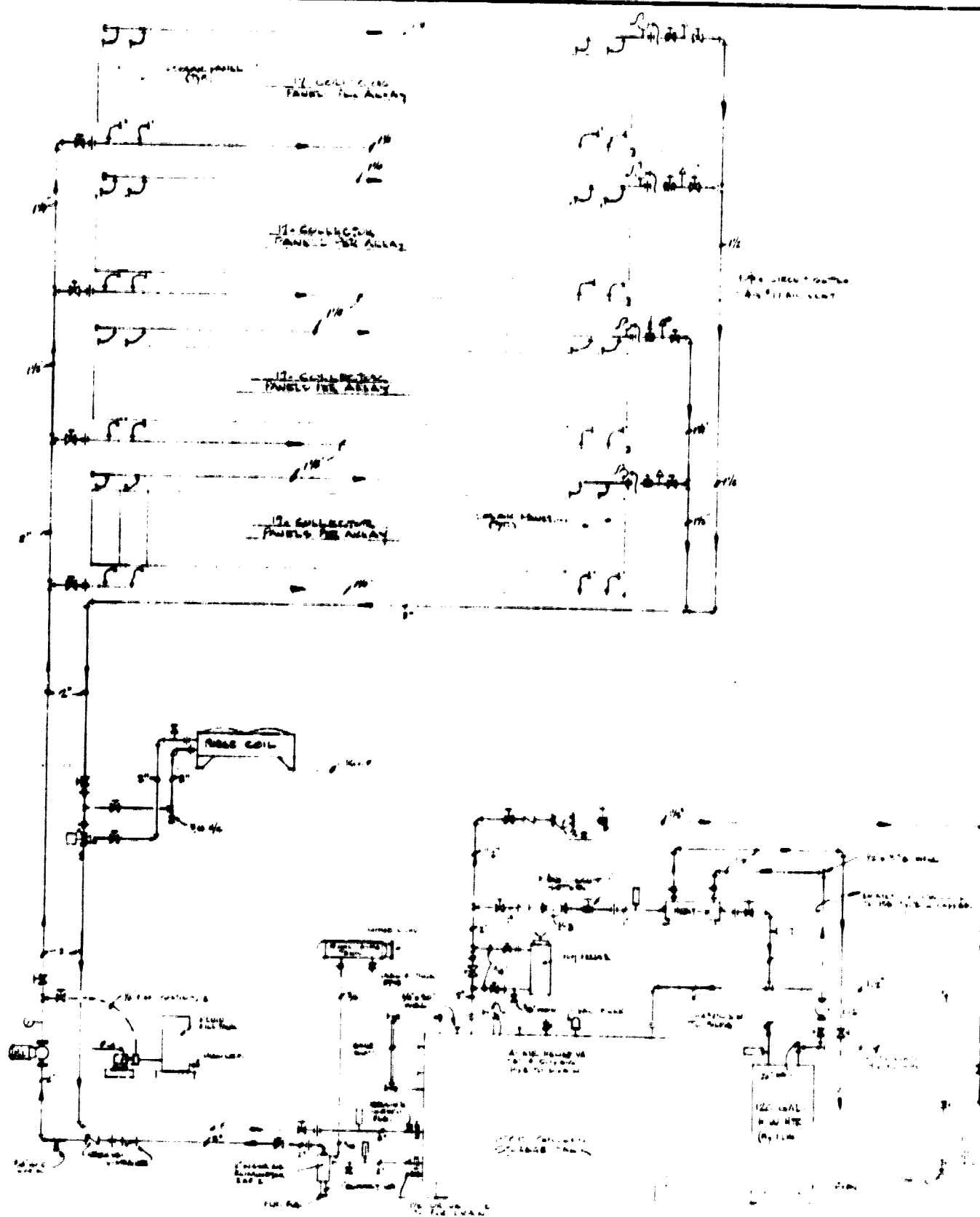
LEGEND BRAG 2

**AS BUILT DRAWINGS**

NORTH WIND LOOK AHEAD  
LEFT HAND SIDE OF THE BUILDING

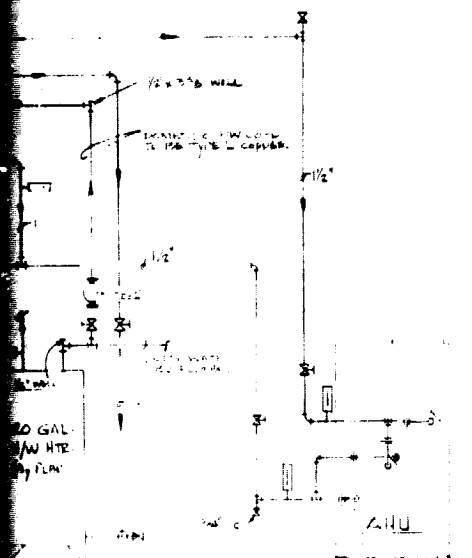
7-12-79 REVISED NASH & HERRING CONTRACT  
REVISED: 8-10-79 (TOWER AREA AND PARTIAL)  
REVISED: 11-15-79  
1. 2" AIR SPACE CHANGES BY 1/2" (SEE PLAN)  
2. 1" AIR SPACE CHANGES BY 1/2" (SEE PLAN)  
3. 2" AIR SPACE CHANGES BY 1/2" (SEE PLAN)  
4. 2" AIR SPACE CHANGES BY 1/2" (SEE PLAN)  
5. 2" AIR SPACE CHANGES BY 1/2" (SEE PLAN)  
6. 2" AIR SPACE CHANGES BY 1/2" (SEE PLAN)  
7. 2" AIR SPACE CHANGES BY 1/2" (SEE PLAN)  
8. 2" AIR SPACE CHANGES BY 1/2" (SEE PLAN)  
9. 2" AIR SPACE CHANGES BY 1/2" (SEE PLAN)  
10. 2" AIR SPACE CHANGES BY 1/2" (SEE PLAN)

REVISION	DATE	BY	DESCRIPTION
1	8-10-79	SHONEY'S	REVISIONS
2	11-15-79	SHONEY'S	REVISIONS
3	8-10-79	SHONEY'S	REVISIONS
4	8-10-79	SHONEY'S	REVISIONS
5	8-10-79	SHONEY'S	REVISIONS
6	8-10-79	SHONEY'S	REVISIONS
7	8-10-79	SHONEY'S	REVISIONS
8	8-10-79	SHONEY'S	REVISIONS
9	8-10-79	SHONEY'S	REVISIONS
10	8-10-79	SHONEY'S	REVISIONS



Handwritten notes or signature at the bottom left of the diagram.

**BOLDOUT FRAME 2**



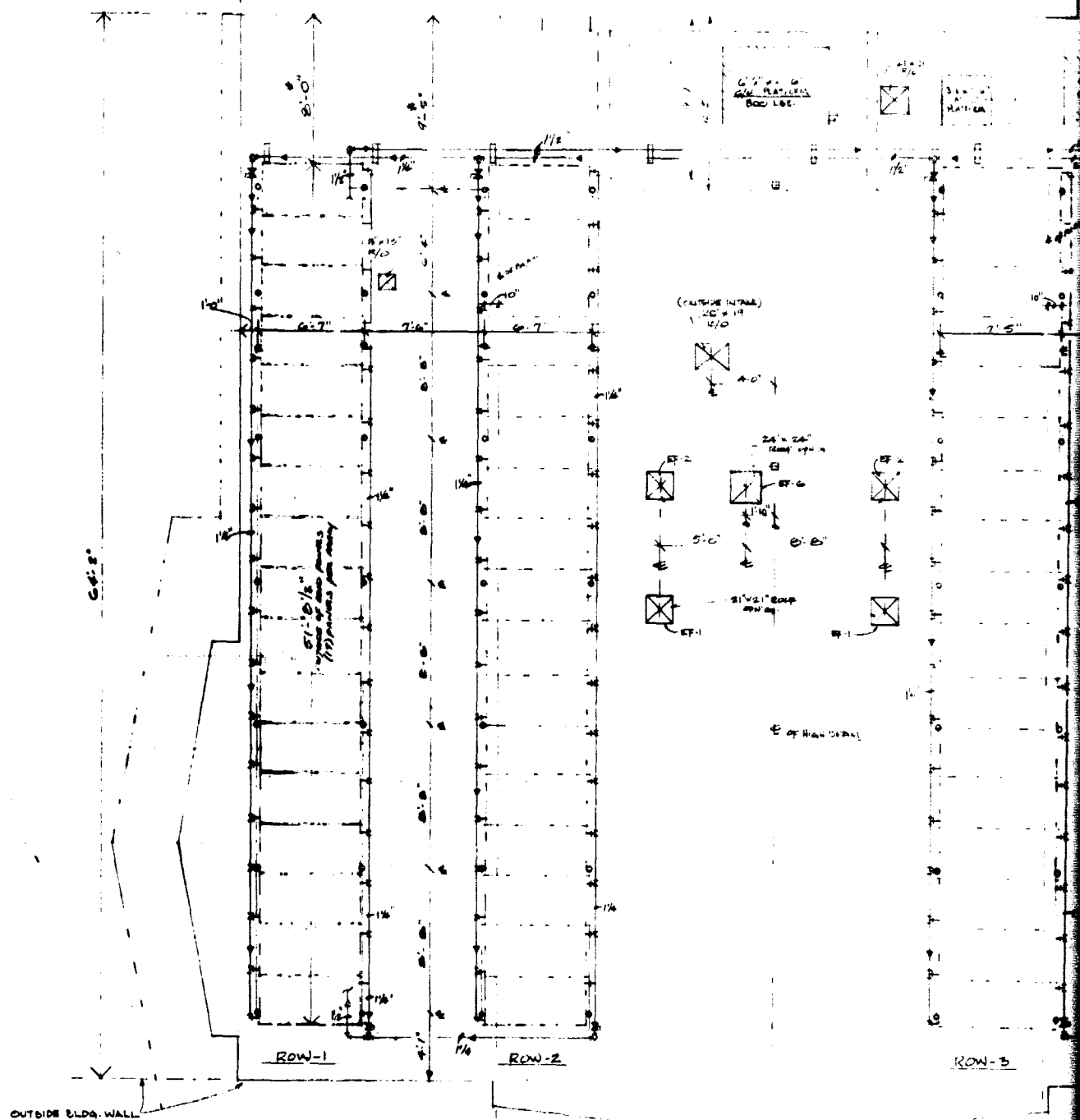
SYMBOL

- THERMOMETER RANGE 30-240 F EXCEPT AS NOTED
- GATE VALVE
- CHECK VALVE
- B & G CIRCUIT SETTER
- RELIEF VALVE
- 1/2" MANUAL PETCOCK AIR VENT
- 3/4" HOSE LOCK (DRAIN)
- AUTOMATIC AIR VENT IS N.T.
- PRESSURE GAUGE

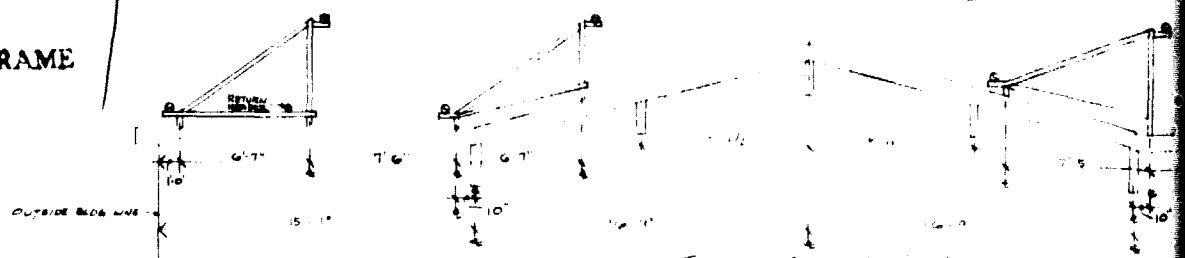
AS BUILT DRAWINGS  
SOLAR HEATING PROJECT

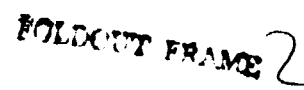
<b>CHONEY'S #347</b>		ALABAMA	
DATE	APPROVED BY	SCALE	DESIGNED BY
7/14/10			
<b>STEPHENS PROS. INC.</b>		MEMPHIS, TENN.	
2222 YORK		DRAWING NUMBER	
		<b>M-2</b>	

71'-2"  
OUTSIDE PLUMB LINE



FOLDOUT FRAME





SEARCHED
EX. H.
INDEXED
DATE
7-26-79
SCALE
1/4" = 1' 0"
JOB NO.
SHEET
M-3
OF SHEETS